Module Catalog

M.Sc. Sustainable Resource Management
TUM School of Life Sciences
Technische Universität München

www.tum.de/
www.wzw.tum.de/index.php?id=2&L=1
Module Catalog: General Information and Notes to the Reader

What is the module catalog?
One of the central components of the Bologna Process consists in the modularization of university curricula, that is, the transition of universities away from earlier seminar/lecture systems to a modular system in which thematically-related courses are bundled together into blocks, or modules.
This module catalog contains descriptions of all modules offered in the course of study.
Serving the goal of transparency in higher education, it provides students, potential students and other internal and external parties with information on the content of individual modules, the goals of academic qualification targeted in each module, as well as their qualitative and quantitative requirements.

Notes to the reader:

Updated Information
An updated module catalog reflecting the current status of module contents and requirements is published every semester. The date on which the module catalog was generated in TUMonline is printed in the footer.

Non-binding Information
Module descriptions serve to increase transparency and improve student orientation with respect to course offerings. They are not legally-binding. Individual modifications of described contents may occur in praxis.
Legally-binding information on all questions concerning the study program and examinations can be found in the subject-specific academic and examination regulations (FPSO) of individual programs, as well as in the general academic and examination regulations of TUM (APSO).

Elective modules
Please note that generally not all elective modules offered within the study program are listed in the module catalog.
Index of module handbook descriptions (SPO tree)
Alphabetical index can be found on page 290


Required Modules | Pflichtmodule

[WZ1821] Natural Resources - Traits, Management and Theory of Sustainability | Natural Resources - Traits, Management and Theory of Sustainability

[WZ1824] System Analysis and Introduction to Ecology | System Analysis and Introduction to Ecology


[WZ1823] Inventory Methods, Statistics and GIS | Inventory Methods, Statistics and GIS

Management Aspects | Management Aspects

[WZ1822] Introduction to Economics and Business Ethics | Introduction to Economics and Business Ethics

[WZ2712] Project Management and Cross Cultural Communication | Project Management and Cross Cultural Communication

[WZ2714] General Education Subject | General Education Subject

   [CLA11301] Presentation Training with Video Feedback | Präsentationstraining vor der Kamera

   [CLA20710] Global Diversity Training | Global Diversity Training

Elective Courses | Wahlmodule

Science Topics | Science Topics

Management and Protection of Forest Ecosystems | Management and Protection of Forest Ecosystems

[WZ4161] Forest Management | Forest Management

[WZ2716] Forest Growth and Forest Operations | Forest Growth and Forest Operations

[WZ2717] Genetic Resources Management and Forest Protection | Genetic Resources Management and Forest Protection

[WZ4082] Plantation Forestry and Agroforestry | Plantation Forestry and Agroforestry

Wildlife and Protected Area Management | Wildlife and Protected Area Management

[WZ4197] Protected Areas Biodiversity and Management | Protected Areas Biodiversity and Management


[WZ4189] Fisheries and Aquatic Conservation | Fisheries and Aquatic Conservation

Module Catalog of the study program M.Sc. Sustainable Resource Management
Generated on 12.12.2022
Landscape Management | Landscape Management 49
[WZ2719] Landscape Planning | Landscape Planning 51 - 52
[WZ4094] Landscape Management - Application Study | Landscape Management - Application Study 56 - 57
Renewable Resources | Renewable Resources 58
[WZ2720] Renewable Energy Technologies | Renewable Energy Technologies 61 - 62
[WZ2721] Agriculture Raw Materials and their Utilization | Agriculture Raw Materials and their Utilization [ARM&U] 63 - 64
[WZ4202] Political and Social Perspectives of Renewable Resources | Political and Social Perspectives of Renewable Resources 67 - 68
[El70860] Integration of Renewable Energies | Integration of Renewable Energies [IRE] 69 - 70
Climate, Air and Water | Climate, Air and Water 71
[WZ2722] Mountain Catchments under Changing Climate | Mountain Catchments under Changing Climate 73 - 74
[WZ2732] Environmental Monitoring and Data Analysis | Environmental Monitoring and Data Analysis 75 - 76
[WZ2730] Climate Change - Science, Impacts and Adaptation, Mitigation | Climate Change - Science, Impacts and Adaptation, Mitigation 77 - 78
| Soils and Soil Management 79
[WZ2733] Introduction to Soil Science | Introduction to Soil Science 79 - 80
[WZ2734] Soil Protection | Soil Protection 81 - 82
[WZ2735] World Soil Resources | World Soil Resources 83 - 84
[WZ2736] Analytical Characterization of Soil Resources | Analytical Characterization of Soil Resources 85 - 86
Material and Waste Management | Material and Waste Management 87
[WZ2724] Emission Control in Land-Use and Animal Husbandry | 87 - 88
Emission Control in Land-Use and Animal Husbandry
[ED160017] Sustainable Manufacturing | Nachhaltige Produktion [SuM] 91 - 93
[WZ2723] Utilization and Treatment of Special Materials and Waste | Utilization and Treatment of Special Materials and Waste
[BGU38014] Water and Wastewater Treatment Engineering | Wasserversorgung, Wasseraufbereitung und Abwasserbehandlung
Sustainable Agricultural Value Chains | Sustainable Agricultural Value Chains
[WZ1876] Entrepreneurship in the Agricultural and Horticultural Industry | Entrepreneurship in the Agricultural and Horticultural Industry
[WI001190] Cooperation and Integration in Agribusiness | Cooperation and Integration in Agribusiness
[WI001215] Network and stakeholder analysis: Sustainable resource use and agri-food system | Network and stakeholder analysis: Sustainable resource use and agri-food system
Free Elective Modules | Free Elective Modules
[BGU38019] Anaerobic Processes and Energy Recovery | Anaerobtechnik und Energierückgewinnung
[CS0126] Advanced Seminar in Circular Economy and Sustainability Management | Advanced Seminar in Circular Economy and Sustainability Management [ASCESM]
[WZ2721] Agriculture Raw Materials and their Utilization | Agriculture Raw Materials and their Utilization [ARM&U]
[WZ2736] Analytical Characterization of Soil Resources | Analytical Characterization of Soil Resources
[WZ2757] Advanced Environmental and Natural Resource Economics | Advanced Environmental and Natural Resource Economics
[WI001190] Cooperation and Integration in Agribusiness | Cooperation and Integration in Agribusiness
<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EI7467</td>
<td>Interdisciplinary Project Internship Concept Development of a Renewable Energy</td>
<td>183 - 185</td>
</tr>
<tr>
<td>LS50000</td>
<td>International Climate Strategies / UNFCCC</td>
<td>186 - 188</td>
</tr>
<tr>
<td>WZ2733</td>
<td>Introduction to Soil Science</td>
<td>189 - 190</td>
</tr>
<tr>
<td>WZ4094</td>
<td>Landscape Management - Application Study</td>
<td>191 - 192</td>
</tr>
<tr>
<td>WZ2722</td>
<td>Mountain Catchments under Changing Climate</td>
<td>193 - 194</td>
</tr>
<tr>
<td>WZ4206</td>
<td>Material Flow Management and Applications</td>
<td>195 - 196</td>
</tr>
<tr>
<td>BGU38023</td>
<td>Engineered Natural Treatment Systems</td>
<td>197 - 198</td>
</tr>
<tr>
<td>ED160017</td>
<td>Sustainable Manufacturing</td>
<td>199 - 201</td>
</tr>
<tr>
<td>WI001215</td>
<td>Network and stakeholder analysis: Sustainable resource use and agri-food system</td>
<td>202 - 204</td>
</tr>
<tr>
<td>WZ2719</td>
<td>Landscape Planning</td>
<td>205 - 206</td>
</tr>
<tr>
<td>EI74831</td>
<td>Project Lab Renewable and Sustainable Energy Systems</td>
<td>207 - 209</td>
</tr>
<tr>
<td>WI001205</td>
<td>People in Organizations: Managing Change and Sustainability in Agribusiness and the Food Industry</td>
<td>210 - 212</td>
</tr>
<tr>
<td>WZ4082</td>
<td>Plantation Forestry and Agroforestry</td>
<td>213 - 215</td>
</tr>
<tr>
<td>WZ4197</td>
<td>Protected Areas Biodiversity and Management</td>
<td>216 - 217</td>
</tr>
<tr>
<td>WZ4202</td>
<td>Political and Social Perspectives of Renewable Resources</td>
<td>218 - 219</td>
</tr>
<tr>
<td>LS10003</td>
<td>Remote Sensing of Agriculture and Vegetation</td>
<td>220 - 221</td>
</tr>
<tr>
<td>LS10004</td>
<td>Research Project ‘Smart Agriculture’</td>
<td>222 - 224</td>
</tr>
<tr>
<td>LS10007</td>
<td>Remediation of Contaminated Sites – Lecture and Seminar</td>
<td>225 - 226</td>
</tr>
<tr>
<td>LS20016</td>
<td>Rhizosphere Research</td>
<td>227 - 229</td>
</tr>
<tr>
<td>POL40100</td>
<td>Introduction to Politics &amp; Technology</td>
<td>230 - 231</td>
</tr>
</tbody>
</table>
Course Achievement | Studienleistungen 285
[WZ4061] Internship | Internship 285 - 287
Master's Thesis | Master's Thesis 288
Required Modules | Pflichtmodule

Module Description

WZ1821: Natural Resources - Traits, Management and Theory of Sustainability | Natural Resources - Traits, Management and Theory of Sustainability

Natural Resources - Traits, Management, Theory of Sustainability

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The intended learning outcomes as defined below require a differentiated way of examination. A written exam (Klausur, 90 min) at the end of the semester will test whether the students sufficiently understand sustainability concepts and their connection to specific resources. As a midterm course achievement (voluntarily), external lecturer Dr. Savage offers the students topics for writing short reports about current global resource management problems as a homework, where they should show their ability to research and structure information and to identify crucial information gaps. Successful performance will improve the exam grade by 0.3.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
The module is intended to be a leitmotif during the first semester.

It consists of three basic units:

Unit 1 introduces the theory and the history of sustainability, supplemented by introducing interdisciplinary method knowledge.
Unit 2 introduces important natural resources, their specific traits in combination with sustainability challenges. Unit 3 discusses case studies from interdisciplinary real-world-implementations.

Lecturers change during the semester. Each lecture is given by an expert in the specific field.

**Intended Learning Outcomes:**
At the end of the module the students understand the most important theories and perceptions of sustainable resource management as well as traits and challenges connected with essential natural resources. Moreover, they are able to apply this knowledge for critically questioning given real-world situations. This comprises the ability to assess strengths and weaknesses of given problem solution approaches (as presented in the media or specialist literature), and to outline possible approaches if confronted with a resource management problem.

**Teaching and Learning Methods:**
Depending on each lecture’s specific contents and due to the modules’ interdisciplinary character, teaching methods combine classic presentations, blended learning and group work.

**Media:**
presentations, worksheets, simulation models

**Reading List:**
Recommended up-to-date readings are supplied by the specific lecturers

**Responsible for Module:**
Biber, Peter; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Natural Resources - Traits, Management, Theory of Sustainability (Vorlesung, 5 SWS)
For further information in this module, please click campus.tum.de or here.
Module Description

WZ1824: System Analysis and Introduction to Ecology | System Analysis and Introduction to Ecology

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a written exam (Klausur, duration 90 min), the students' understanding of important ecological concepts and ecosystem dynamics' patterns is assessed. Moreover, in the same exam, we test their understanding of system analysis methods and their ability to apply them in ecological and other contexts by correctly solving specific problems given in the questions.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
This module combines an introduction to ecology with an introduction to analyzing and modelling dynamic systems. As ecosystems are intrinsically dynamic, i.e. governed by feedback structures, understanding dynamic systems is a key qualification for understanding ecological theory. By examples from ecology but also from other fields (in which cases, however, transfers to ecological applications are always highlighted) formal key methods in structuring system knowledge, building computer models, and learning from such models are taught. An important insight to convey is the interdisciplinarity of dynamic systems and the related methods: Feedback structures found in ecosystems can often as well be found in social science or engineering contexts and vice versa. Parallely, students get basic and advanced insights into fundamental elements of ecological concepts (e.g. modularity, unitarity, speciation, populations, metapopulations, competition, mutualism, ecosystems and their functions) and theory from the level of organisms to populations to species interactions up to the ecosystem level.
**Intended Learning Outcomes:**
At the end of the module students understand essential elements of ecological theory and concepts. They remember important dynamic patterns and the ecological concepts behind. Moreover, they are able to apply key methods of system analysis to small and intermediate problems in ecology but also in other fields. The latter abilities include using causal loop diagrams and stock-and-flow diagrams for structuring information, understanding the basic mathematics behind dynamic models, being able to build small and intermediate simulation models, and to develop an understanding of the potential and limitations of computer simulations in general.

**Teaching and Learning Methods:**
Lecture providing theoretical foundations in ecology. Interactive lecture in System Analysis, with an individual workstation being available for each student. In the beginning, the group is closely guided through simple problems in order to develop routine in the methodological and technical basics while understanding fundamental dynamic processes from exponential growth and decay up to nth order delays. Along with their increasing skills, students are given the opportunity to work more independently, with individual guidance upon request, about problems like different approaches to sustainable harvest or overshoot and collapse systems. This concept allows the lecturer to adjust the share of frontal teaching and independent work to the group’s learning progress.

**Media:**
Reading material provided by lecturers, power point presentations, modelling software VENSIM PLE, example models

**Reading List:**

**Responsible for Module:**
Biber, Peter; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
System Analysis (Vorlesung, 2 SWS)  
Biber P

Introduction into Ecology (Vorlesung, 2 SWS)  

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2713: Methods of Scientific Communication | Methods of Scientific Communication

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a research paper that is the means to evaluate whether the students are able to apply the regulations of scientific writing in their own scientific paper. This assignment will be complemented by presentations of various lengths for the purpose of assessing the student's communication competency in presenting scholarly work to an audience.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None.

Content:
The students acquire detailed and differentiated knowledge of oral and written scientific communication including the following topics:
- the communication process as two-way interaction
- group dynamics, dealing with difficult situations and facilitating conflict resolution in groups
- purpose of scientific writing
- procedure of scientific writing
- process of writing a scientific paper
- content details of the different chapters in a scientific paper
- looking for literature and data sources to write a scientific paper
- reflection of reviews
- English style of presentations
- how to express transition points
- how to describe tables, graphs and charts
- key characteristics of effective presentations
- the special features of scientific presentations
- the structural elements of a presentation
- vocal skills and body language, using and managing visual aids, persuasive language and delivery techniques
- dealing with nervousness, breaking the ice, handling questions and difficult situations
- different facilitation opportunities, challenges, and problems, verbal and nonverbal facilitation techniques, step-by-step facilitation processes and tools.

**Intended Learning Outcomes:**

By the means of the module the students are able to:
- identify the elements of and barriers to communication
- understand the topic scientific writing
- apply the procedure of scientific writing
- analyze other scientific papers
- apply literature sources
- create and deliver own scientific papers
- understand the importance of a good presentation
- recognize the features of an excellent presentation
- apply the key elements of presentation
- analyze a presentation’s situation (purpose/audience/roles),
- create and deliver own presentations (effectively plan, research, and structure their presentation).

**Teaching and Learning Methods:**

Concerning teaching methods, lecture and presentation parts provide theoretical foundations in both scientific writing and presenting. Exercises are introduced to the students who are tasked with completing them individually as homework. In order to familiarize students with the process of scientific writing, they work in groups to study specialist literature and data files that form the basis for writing a scientific paper as homework under time constraint. On basis of critique reviews and feedback sessions by the lecturers, they revise the scientific paper. As complement, every student prepares and holds oral presentations in the seminar, offering constructive feedback to peers guided by the lecturer, who also provides feedback.

**Media:**

Power point presentation, black board, flip chart, pin board, lecture sheets, PDFs of scientific papers, PDFs of Guidelines.
Reading List:
TUM citation guideline
Summary guideline "How to write a scientific paper" within the seminar.
Other documents within the seminar.

Responsible for Module:
Weber-Blaschke, Gabriele; Apl. Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Presenting (Seminar, 3 SWS)
Davies A

Scientific Writing (Seminar, 2 SWS)
Weber-Blaschke G, Hijazi O
For further information in this module, please click campus.tum.de or here.
Module Description

WZ1823: Inventory Methods, Statistics and GIS | Inventory Methods, Statistics and GIS

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level: Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
<th>Frequency: winter semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits:* 6</td>
<td>Total Hours: 180</td>
<td>Self-study Hours: 110</td>
<td>Contact Hours: 70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning success will be assessed by a written examination covering the knowledge and competence achieved in the three main branches of the module, namely GIS, Terrestrial Inventory Methods, Remote Sensing (RS), and Statistics. In GIS, a basic understanding of various GIS concepts and problem solution strategies is referred to.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
Implementation of basic concepts for acquisition, management, visualization of spatial data, and data evaluation as well as their inter-connection with tabular data from different source.
1. GIS: the focus is on the use of vector based GIS; the potentials of raster based GIS are demonstrated.
2. Terrestrial Inventory Methods: Introduction to sampling theory and application.
3. Remote Sensing (RS): Introduction to RS Principles: basic understanding of the physical background, on sensor concepts, evaluation strategies and spatial information extraction are elucidated.

Intended Learning Outcomes:
At the end of the courses on Inventory methods, GIS and Statistics the students are able to:
- select an appropriate GIS/Image Analysis program with respect to its intended field of application;
- apply a Geoinformatics tool (GIS and RS) to solve individual problems dealing with spatial information.
- understand the principles of sampling and how to assure the quality of a sample.
- understand the basic principles of remote sensing
- identify a geospatial problem and to decide on the appropriate RS system as well as on the data analysis strategy for the task to be supported.
- understand data analysis as a support for their Master's Thesis, understanding the formulation of hypotheses, the connection of statistics to epistemology, their preconditions for proper application and interpretation of the results, applying important statistical techniques.

Teaching and Learning Methods:
The module includes lectures, exercises and accompanying examples.

Media:
Online material available at www.elearning.tum.de; Slides with lectures downloadable from a platform to be announced.

Reading List:

Responsible for Module:
Knoke, Thomas; Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to GIS (Vorlesung mit integrierten Übungen, 2 SWS)
Döllerer M

Statistics (Vorlesung, 1 SWS)
Knoke T

Inventory Methods (Vorlesung, 2 SWS)
Knoke T, Mengesha M
For further information in this module, please click campus.tum.de or here.
Management Aspects | Management Aspects

Module Description

WZ1822: Introduction to Economics and Business Ethics | Introduction to Economics and Business Ethics

Version of module description: Gültig ab summerterm 2015

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Current notice: Due to the continuing CoViD19-pandemic, the exam for this winter semester 2020/21 has been adjusted.
Students have the opportunity to participate in the written online examination, Online Proctored Exam (Onlineprüfungen: WZ1822o, WZ1822-1o und WZ1822-2o). These exams will parallely be held as regular written exam in person (WZ1822, WZ1822-1 und WZ1822-2).
The written examination assesses the students’ understanding of the basic concepts of microeconomic theory (module part introduction to economics) and major business ethical concepts and issues. Furthermore, the examination tests students’ ability to precisely describe solutions, achieve certain results and reproduce standard arguments within a limited amount of time.
A Mid-Term assignment (presentation) assesses the students’ ability to present a new topic in a comprehensible manner. It will serve for grade improvement by 0.3 according to §6 (5) APSO.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
The module is an introduction to Business Ethics and Economics. Business ethics introduces the student to classical concepts of duty, consequentialism and virtues, in particular modern management virtues. The classical concepts are applied to corporate social responsibility
and corporate governance. CSR and corporate governance will be discussed in the light of globalization, the financial crisis of 2008 and major corporate scandals.

The module part “Introduction to Economics” provides an introduction into microeconomic theory and the interaction between economics and the environment. Based on consumer and producer theory, we analyze the interactions of demand and supply on markets. We analyze economic reasons for market failure and use welfare economic concepts to evaluate market interventions. In the final part, we look at principles of intertemporal efficiency and an economic perspective of sustainability.

**Intended Learning Outcomes:**
The major theoretical positions are reflected in public as well as private debates. Thus, understanding the structure of standard arguments contributes to the development of solution-oriented approach to ethical dilemmas and to the students’ rhetorical skills.

We will take hands on approach to CSR, focusing on Un Global Compact and specific CSR policies. This approach will prepare the student for practical challenges of implementing CSR policies. We will approach Corporate Governance in a similar manner, looking at cases of bad corporate governance, at codes of corporate governance and at the practical challenges of implementing stricter procedures in the organizations.

The lectures on power will introduce the students to a significant aspect of organizational interaction. We look at different ways to obtain power in an organizational context and we will investigate the opportunity for ethical action in a professional environment characterized by a more or less intensive power struggles. The analysis of consumer ethics will clarify why our environmentally damaging consumer habits are so difficult to change.

Students will learn about ways in which the economy and the environment are independent. They will understand the microeconomic theory of consumer and producer behaviour and reasons for market failure. They will be able to apply welfare economics to evaluate governmental market interventions. Furthermore, they will understand the temporal dimension of economic decisions and their implications for sustainability.

**Teaching and Learning Methods:**
2/3 lectures, 1/3 group work and student presentations

**Media:**

**Reading List:**
The texts will be provided on moodle

**Responsible for Module:**
PD. Dr. Thilo Glebe – Lehrstuhl für Volkswirtschaftslehre - Umweltökonomie und Agrarpolitik Alte Akademie 14; 85354 Freising; 08161-71-5965; glebe@wzw.tum.de
Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Economics (WZ1822) (Vorlesung, 2 SWS)
Glebe T [L], Glebe T

(WZ1822) Business Ethics (Vorlesung, 2 SWS)
Thejls Ziegler M
For further information in this module, please click campus.tum.de or here.
## Module Description

**WZ2712: Project Management and Cross Cultural Communication**

**Project Management and Cross Cultural Communication**

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

### Description of Examination Method:

The examination consists of a written project report (10 pages) comprising a description of the relevant project planning tools. Additionally, an oral group presentation of the results is required. The project work will validate the student’s ability to transform their project ideas into a project proposal including a corresponding work breakdown structure, while the presentation will allow assessing the ability to present a project idea to a professional audience, and to conduct a discussion about the presented issues. A voluntary mid-term assignment in form of a written report (2 pages) allows students to demonstrate their learning in cross-cultural communication. This assignment allows improving the examination mark by 0.3, and will be evaluated in a mid-term examination in the form of a written report.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

None

**Content:**

Objectives, dimensions and characteristics of project management; types of projects; project life cycle phases and work breakdown structures; project network diagrams and milestone plans; stakeholder analysis and management; risk analysis and management in projects; critical path method; financial project planning; project resource planning and control; team building skills. Dimensional model of culture; theory and practice of cross-cultural communication, exercises in dealing with different perceptions.
**Intended Learning Outcomes:**
At the end of the module, students are able to develop a detailed project plan and to understand related communication processes as well as apply that understanding to improve their task performance. They can present their results to specific target audiences in an organized manner. Additionally, they can organize ideas effectively and communicate them in a well-developed written report. Furthermore, students are able to understand cross-cultural differences and to apply techniques to avoid miscommunication in project management rooted in cross-cultural differences.

**Teaching and Learning Methods:**
Knowledge and skills are imparted by lectures as well as the flipped classroom method, individual and group work, presentation of case studies and peer discussions; the learning methods are definition and solving of problems, collaborative work, group discussions, preparation and implementation of presentations, report writing.

**Media:**
PowerPoint presentations, case studies, presentation notes and online resources

**Reading List:**

**Responsible for Module:**
Bitsch, Vera; Prof. Dr. Dr. h.c.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Project Management (Vorlesung, 4 SWS)
Bitsch V [L], Bitsch V, Abate Kassa G

Cross Cultural Communications (Seminar, 1 SWS)
Bitsch V [L], Bitsch V, Abate Kassa G

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
WZ2714: General Education Subject | General Education Subject

Module Description

CLA11301: Presentation Training with Video Feedback | Präsentationstraining vor der Kamera

Version of module description: Gültig ab summerterm 2015

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor/Master</td>
<td>German</td>
<td>one semester</td>
<td>irregularly</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>7</td>
<td>23</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In einer Präsentation (10-15 Min.) zeigen die Studierenden, dass sie sicher präsentieren können und wissen wie man anhand der Körpersprache überzeugt und wirkungsvoll zu einem Publikum spricht.

Repeat Examination:

(Recommended) Prerequisites:

Content:
Im Workshop analysieren und üben Studierende, was eine gute Präsentation ausmacht und wie Körpertechik, Körperhaltung und Sprache für einen bleibenden Eindruck eingesetzt werden können. Anhand von Videoanalysen erhalten die Studierenden konstruktives Feedback.

Präsentationen können auch in englischer Sprache gehalten werden.

Themen
- Körpersprachliche und stimmliche Wirkung
- Umgang mit Lampenfieber
- Einsatz von Medien
- Umgang mit Einwänden aus dem Publikum
**Intended Learning Outcomes:**
Nach der Teilnahme sind die Studierenden in der Lage
- sicher und authentisch vor Publikum (und Kamera) aufzutreten
- körpersprachliche Wirkungselemente souverän einzusetzen
- Präsentationen publikumsorientiert und überzeugend zu gestalten

**Teaching and Learning Methods:**
Input, Präsentieren, Video-Feedback

**Media:**

**Reading List:**

**Responsible for Module:**
Bettina Hafner

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click campus.tum.de or here.
Module Description

CLA20710: Global Diversity Training | Global Diversity Training

Version of module description: Gültig ab winterterm 2013/14

<table>
<thead>
<tr>
<th>Module Level: Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
<th>Frequency: winter/summer semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits:* 2</td>
<td>Total Hours: 60</td>
<td>Self-study Hours: 38</td>
<td>Contact Hours: 22</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students will deal with their own cultural background in a short group presentation and deeply reflect on the learning outcomes of the workshop in a learning summary (100% of grade).

Repeat Examination:

(Recommended) Prerequisites:

Content:
Collaboration in international teams is becoming a crucial everyday part of working environments. It brings numerous benefits, but can also lead to misunderstandings, confusions and conflicts that can hinder productivity.

The aim of the training is to prepare participants for teamwork from an intercultural perspective and especially to reflect the influence of diversity on the team process in international teams. To achieve this goal, we will work with science-based models, short lectures and numerous exercises with a strong focus on the relevance for your professional and daily life.

Intended Learning Outcomes:
After this workshop you will be able to individually deal with our own cultural background and its impact on intercultural collaboration
- Analyze the role and tasks of team leaders in an intercultural context.
- Develop strategies for case studies in international teams.
- be able to analyze situations of your professional life in an international team.
Teaching and Learning Methods:
The workshop will be a mix of input, case studies, discussions and group work.

Media:

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Global Diversity (Successful in International Teams) (Workshop, 1,5 SWS)
Prahl M
For further information in this module, please click campus.tum.de or here.
Elective Courses | Wahlmodule

Science Topics | Science Topics

Management and Protection of Forest Ecosystems | Management and Protection of Forest Ecosystems

Module Description

WZ4161: Forest Management | Forest Management

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module integrates different scientific and management methods with the objective to develop concepts for the sustainable management of forest. Forest managers must understand complex content and be able to explain it to a critical audience. The learning outcome will be assessed by an oral exam (30 minutes) covering the whole outcomes of the module.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None.

Content:
1. Definition of forest and forest ecosystem
2. Overview of forestry on global, regional and local scales
3. Introduction into objectives and methods of forest ecosystem management and forest management planning
4. Demonstration of forest decision support systems and multiple-objective optimization
5. Overview of silvicultural techniques
6. Basic Knowledge of Forest economics
7. Demonstration of examples in lowland and mountain forest management.

**Intended Learning Outcomes:**
At the end of the module the students are able to:

- understand different concepts of forest management
- understand different demands in forest management
- apply means of linear programming to harmonize different measures
- apply decision support systems
- evaluate different forest management measures.

**Teaching and Learning Methods:**
The module is separated into lectures and exercises. Lectures providing the theoretical foundations and concepts in Forest Management. Exercises are done in supervised groups in the field.

**Media:**
PowerPoint presentations, additional reading material, software application.

**Reading List:**

**Responsible for Module:**
Felbermeier, Bernhard; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click campus.tum.de or here.
**Module Description**

**WZ2716: Forest Growth and Forest Operations | Forest Growth and Forest Operations**

Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

**Description of Examination Method:**
The learning success of the module Forest Growth and Forest Operations will be assessed by a written examination of 90 minutes. This is due to the fact that biometric topics, growth processes and analyses as well as the forest growth modelling part of the lecture can be presented best in a written form by drawings, figures, calculation schemes, etc. For example, the description of biological processes and growth cycles in forest growth simulators can best be explained and depicted by graphical representations.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in biology and forest science.

**Content:**
The part Forest Growth deals with objectives and methods of forest growth and yield science. First, as fundamental topic, principal factors of the organic production of forest stands based on the driving forces (climate, water, nutrients) are shown and explained. In a next step growth and yield is analyzed more closely as part of the total production of plant communities. This leads to principles of tree shape development, tree growth and carbon dynamics in general. From individual tree growth the course proceeds to structure and development of whole forest stands. Both previous subjects provide the basic knowledge for understanding the effect of silvicultural treatment on quantitatively measured growth and yield characteristics. Growth trends, productivity and carbon dynamics of the main tree species in Central Europe are presented. Analyses of stand structure, growth and yield in the view of climate change are discussed. Different types of forest growth models on tree, stand and forest enterprise levels are introduced. The part Forest Operations can be divided in 5 topics: (1) Overview of mechanized harvesting (methods and
most common systems), (2) Environmentally sound resource road planning and construction, (3) Assessing the environmental impacts of forest operations on forest stands and soils, (4) Means of eco-efficient wood transportation from the forest to the mill and (5) Current developments in small-scale forest operations.

**Intended Learning Outcomes:**
On successful completion of the module, students are able to
- Understand the environmental factors influencing the forest stand production
- Describe the effects of silvicultural treatment on quantitatively measured growth and yield characteristics
- Understand the principles of growth models
- Analyze and evaluate the impact of environmental changes on tree and stand growth
- Create possible silvicultural measures to mitigate negative effects of environmental changes on forest stand growth
- Understand and evaluate the impact of biotic and abiotic factors on growth, vitality and stability of individual trees and forest stands
- Understand the fundamentals of sound resource road planning and construction
- Describe the links between mechanized harvesting and potential stand and soil damages
- Evaluate the productivity and carbon footprint of different harvesting systems.

**Teaching and Learning Methods:**
Lectures and presentations, field trip (optional).

**Media:**
Lectures and presentations (pdfs).

**Reading List:**

**Responsible for Module:**
Rötzer, Thomas; Apl. Prof. Dr. agr. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2717: Genetic Resources Management and Forest Protection | Genetic Resources Management and Forest Protection

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcome will be assessed by a written exam (duration 60 min) where the student have to analyze the risk of given pest and abiotic hazard-scenarios and to develop adequate disturbance management strategies. Furthermore, they have to analyze a genetic diversity study from a plant, animal or fungus species and develop a long-term genetic management strategy. In this way, the students can demonstrate that they have obtained the ability to use their knowledge in real world management situations.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in biology and forest science

Content:
Part I Genetic Resources Management – Schaefer/Benz
1. Introduction: DNA, genetic code, genes, alleles, genomes, speciation
2. Basics of Population Genetics
3. Genetic variation in forest ecosystems
4. Tree breeding
5. Genetic conservation & sampling strategies
6. GRM in mountain ecosystems
7. GRM in the Tropics
8. GRM in the dry zones
9. Sustainable management strategies
10. Fungi – The Good, the Bad, and the Ugly
11. The genetic treasure trove of fungi
Part II Disturbance ecology & management – Seidl/Seibold
1. Disturbance ecology 101 (R. Seidl)
2. The role of disturbances in forest ecosystem dynamics (R. Seidl)
3. Forest protection strategies in the course of time (S. Seibold)
4. Wind (R. Seidl)
5. Snow and ice (R. Seidl)
6. Fire (R. Seidl)
7. Drought (R. Seidl)
8. Functional roles of insects in forest ecosystems (S. Seibold)
9. Bark beetles – ecology (S. Seibold)
10. Bark beetles – management and impacts (S. Seibold)
11. Defoliators (S. Seibold)
12. Aphids, adelgids and others (S. Seibold)
13. Deadwood-inhabiting insects (S. Seibold)
14. Principles of disturbance management (R. Seidl)

Intended Learning Outcomes:
On successful completion of the module, students are able to
- assess genetic diversity patterns in natural populations of different groups of organisms (mammals, birds, plants, fungi)
- understand the importance of maximizing genetic diversity
- understand the impact of biotic and abiotic factors on vitality and stability of individual trees and forests;
- understand the impact of fungal pathogens and insects on trees;
- apply their ecological knowledge to minimize and forecast the risk of damages by fungal pathogens;
- explain the most important abiotic and biotic causes of tree death in forest ecosystems
- characterize forest disturbance regimes
- understand the different roles that disturbances play in forest ecosystems
- explain how plants adapt to different disturbance agents
- develop different disturbance management strategies.

Teaching and Learning Methods:
Lectures and presentations: provide the theoretical population genetics and ecological background to understand the role of genetic diversity in general and the role of disturbance at population level and beyond.
Group work: will be used to learn how to assess and interpret genetic diversity patterns in various real world examples and to practice risk forecasting in disturbance management or develop disturbance management strategies.
Field trip (optional): to help understand the role of disturbance and genetic diversity in a real Bavarian forest setting.
Media:
lectures and presentations (pdfs)

Reading List:

Responsible for Module:
Schäfer, Hanno; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Genetic Resource Management (Vorlesung, 2 SWS)
Benz J, Schäfer H

Disturbance ecology and management (Vorlesung, 2 SWS)
Seidl R [L], Seidl R, Seibold S

For further information in this module, please click campus.tum.de or here.
Module Description

WZ4082: Plantation Forestry and Agroforestry | Plantation Forestry and Agroforestry

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcomes are assessed by an oral examination (30 min). Based on specific problem statements the students have to demonstrate their ability to analyze and assess the situation, to understand the origin of the problem and to propose solutions adapted from the methodologies and techniques procured in the course.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
Plantation forestry: Background, Definitions, Plantations in the Context of International Forest Policy, Plantation Forestry Purposes, Plantation Silviculture, Management and Economics;
Agroforestry (AF): Introduction (global land-use problems, definitions, terminology), Traditional AF Systems, Environmental, economic and socio-cultural aspects of AF, Interactions in AF systems, Important tree groups in AF (NFT´s, MPT´s, Palms), Planning in AF, Legal aspects
Forest Management for Carbon Sequestration: Role of forests in the global carbon cycle, Possible impacts of climate change on forests, International climate policy, Forest in the Kyoto Protocol (KP), Flexible mechanisms of the KP, REDD and REDD+, Forest management options, Modelling forest sequestration with CO2FIX, Case studies.

Intended Learning Outcomes:
Students will be able to
- understand and evaluate the major issues of plantations in the context of international forest policy,
- explain the fundamental purposes of Plantation Forestry,
- properly deploy the essential techniques of Plantation Silviculture, e.g. for establishment, tending and maintenance
- critically examine plantation projects (management, work volume, economic results).
- understand the fundamental principles and practices of agroforestry land use,
- analyze the interactions among different components of an AF system,
- assess the ecological and economic effects of AF-systems and develop adequate management options,
- address problems in the context of rural development and identify AF-based solutions
- understand the role of forests and forest management activities in the global C-cycle,
- assess forest management options for different purposes within the framework of the international climate policy,
- identify and develop concepts for mitigation projects.

**Teaching and Learning Methods:**
Knowledge and skills are imparted by lectures, group discussions, presentation of case studies and small exercises; the learning methods are learning, reviewing scientific articles, and research reference articles. The lectures will provide theories and basic reference materials which will be deepened and proved by reviewing articles. The achieved skills will be used to develop and discuss solutions for specified problems.

**Media:**
PowerPoint presentations, case studies, additional reading material

**Reading List:**

**Responsible for Module:**
Annighöfer, Peter; Prof. Dr.
Courses (Type of course, Weekly hours per semester), Instructor:
Plantation Forestry (Vorlesung, 2 SWS)
Annighöfer P [L], Annighöfer P

Agroforestry and Forest Management for Carbon Sequestration (Vorlesung, 2 SWS)
Annighöfer P [L], Annighöfer P, Thom D
For further information in this module, please click campus.tum.de or here.
Wildlife and Protected Area Management | Wildlife and Protected Area Management

Module Description

WZ4197: Protected Areas Biodiversity and Management | Protected Areas Biodiversity and Management

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Final written examination of 90 minutes in the field of protected areas biodiversity and its management to examine whether the students have understood the problematic of securing biodiversity in protected areas and are able to verify conservation measurements.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful completion of the 1st semester of the Master Program Sustainable Resource Management is recommended

Content:
Biodiversity and protected areas: A worldwide survey on ecozones and altitudinal belts of the world as carriers of natural biodiversity; protection of biological units; IUCN protected areas classification, the European FFH Directive as an example of a continent-wide tool for nature protection.

Habitat analysis and management: Habitat types, tools for protecting habitats, design of management plans, visitor management, best practice examples in sustainable biodiversity and habitat protection.

Intended Learning Outcomes:
On successful completion of the module students are able to:
- to put ecosystems and its utilisation options as well as its threats into a global perspective
- give clear options for further management, both regarding utilisation and protection

**Teaching and Learning Methods:**
Lecture, case studies, practical experiments / demonstrations, discussions.

**Media:**
PowerPoint Presentation.

**Reading List:**

**Responsible for Module:**
Prof. Dr. Ralph Kühn; kuehn@wzw.tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click campus.tum.de or here.
Module Description


Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Written assignment (ca. 15 pages) requiring review of literature, synthesis and integration of key concepts and findings from the literature to develop a coherent research proposal that clearly demonstrates knowledge in the field of species management and conservation strategies and of human dimensions as a research and applied field of study. Expected to read in advance where possible assigned readings so to be prepared for course lectures.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:

Intended Learning Outcomes:
After the course students are able to: understand important ecological concepts in wildlife management; understand the importance of the human dimension in wildlife management; analyse a conservation strategy for a species; apply wildlife management plans; evaluate species
and protected area management plans; understand the importance and nature of objectivity in conducting research and being a human dimension researcher; develop the ability to synthesize relevant literature pertinent to a research problem; organize ideas effectively and communicate these in a well-organized and developed written proposal.

**Teaching and Learning Methods:**
Lecture, video, group exercises, discussions

**Media:**
lecture notes, flip-chart/board, hand-outs, additional reading material

**Reading List:**

**Responsible for Module:**
Kühn, Ralph; Apl. Prof. Dr. agr. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Course 1:
Wildlife Management
Course 2:
Wildlife-Human Interactions

Lecturer 1:
Thomas Rödl
Lecturer 2:
Alistair James Bath

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description

WZ4189: Fisheries and Aquatic Conservation | Fisheries and Aquatic Conservation

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:

Current information regarding the limited activities with physical presence due to the CoViD19-pandemic:

In case the framework requirements (hygiene, distance rules etc.) for examinations with physical presence are not met, the planned examination format can be changed to a digital (remote) examination according to §13a APSO. The decision on this change will be communicated as soon as possible, however latest 14 days before the actual examination date, by the responsible examiner in coordination with the examinations board.

The examination consists of a 60 min. written exam (Klausur). In addition, the students need to prepare a 10-15 min. presentation in the practical exercise. Gradings from the examination and the presentation are weighed in the ratio 2:1.

The examination means to measure the student’s ability to assess anthropogenic influence on aquatic ecosystem functioning, evaluate the socioeconomic importance of fisheries and aquaculture, explain factors affecting susceptibility to and recovery from overexploitation and recall fisheries management tools for wild populations as well as of the underlying biological principles such as fish population dynamics. In the written examination students demonstrate by answering questions under time pressure and without helping material their theoretical and practical (e.g. application of methods) knowledge about fisheries management. For answering the questions, the students require their own wording.

In the practical exercise the students prepare a presentation in form of a brochure, poster, video or podcast. For the presentation, the student is expected to demonstrate that he or she is capable of preparing a certain topic within a given time frame in such a way as to present or report it in a clear and comprehensible manner to specific target audiences in the context of fisheries and aquatic conservation.
Repeat Examination:
Next semester

(Recommended) Prerequisites:
Interest in aquatic biology, social sciences, conservation biology and management; this course can be selected independently from other courses in the fields of Fish Biology and Limnology at TUM

Content:
The module combines the theoretical background and the practical implementation of fisheries management and aquatic conservation. The key aspects are:
1. Introduction to fish, shellfish and fisheries management,
2. The socioeconomic importance of fisheries and aquaculture,
3. The functioning of aquatic ecosystems and the impacts of fisheries on aquatic ecosystem health,
4. Factors affecting susceptibility to and recovery from overexploitation,
5. Fisheries Management Tools for wild populations,
6. Aquaculture,
7. Aquatic Biodiversity Conservation,
8. Case study and knowledge transfer/communication excercise

Intended Learning Outcomes:
At the end of the module students understand the importance of aquatic resources for mankind and the variables which influence ecosystem functions as well as the principles of aquatic biodiversity conservation. They are able to analyze the effects of natural and man-made disturbances in aquatic ecosystems (e.g. overexploitation) based upon an interdisciplinary understanding of methodological aquatic and fisheries biology, human dimensions, socioeconomic factors and management skills. In addition, students are able to objectively integrate knowledge from different disciplines (e.g. fish biology, conservation biology, commercial fishing techniques, aquatic habitat assessment and management) to evaluate sustainable resource management.

Teaching and Learning Methods:
The module combines a lecture "Fisheries Management" with an accompanying practical excercise "Applied Aquatic Conservation". The lecture contents will be presented using lectures based on power-point presentation, group work and interactive role plays in order to combine activating teaching methods with classic presentation techniques. In the accompanying practical excercise to the lecture the students will apply the gained theoretical knowledge by conducting case studies or participating research experiments with various content in the field of freshwater ecology and aquatic conservation. The content of the practical work is incorporated into running research projects at the chair (e.g. habitat restoration, artificial breeding programmes, habitat assessment, conservation genetics). Additionally, the students learn to independently screen the respective literature in this field and learn methods in science communication.
Media:
Form of presentation: lecture, case study, movie segment and practical excercise
material: lecture notes, flip-chart/board, plus different materials for methodological/technical
training

Reading List:
1. King (2007) Fisheries Biology, Assessment and Management
biodiversity and fishery
resources

Responsible for Module:
Geist, Jürgen; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Fisheries Management (Vorlesung, 2 SWS)
Geist J

Applied Aquatic Conservation (Übung, 2 SWS)
Geist J [L], Geist J, Pander J, Stoeckle B, Zingraff-Hamed A
For further information in this module, please click campus.tum.de or here.
Module Description

WZ6432: Wildlife and Conservation Biology | Wildlife and Conservation Biology

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a 60 min. written exam (Klausur). The examination means to measure the student’s ability to assess anthropogenic influence on biodiversity, to explain factors affecting wildlife, to recall methods in conservation biology and applied genetics and to evaluate conservation biology concepts. In the written examination students demonstrate by answering questions under time pressure and without helping material their theoretical and practical knowledge about wildlife and conservation biology. For answering the questions, the students require their own wording. In the practical excercise the students present a case study and design a own research project proposal to practice their scientific communication skills and to transfer the theoretical knowledge to practical projects. Gradings from the Klausur and the Project work are weighed in the ratio 7:3.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Interest in wildlife conservation biology and nature conservation. Basic background in biology

Content:
The module combines the theoretical background and the practical implementation of wildlife conservation biology, conservation genetics and nature conservation. The key aspects are:
1. Scope and tasks of conservation biology and applied genetics
2. Biodiversity, ecosystems, ecosystem services and green banking
3. Factors affecting terrestrial and aquatic biodiversity
4. Methods in wildlife conservation biology and applied genetics
5. Conservation biology concepts and strategies for natural population using international examples
6. Case studies and applied nature conservation, from theory to praxis
Intended Learning Outcomes:
At the end of the module students understand the importance of biodiversity of terrestrial resources and its interaction with human dimensions. They are able to apply and to evaluate Conservation Biology methods and strategies based upon an interdisciplinary understanding of species biology, conservation biology and applied genetics. In addition, students are able to integrate interdisciplinary knowledge into applied conservation management on a regional and international scale. They have an overview of applied interdisciplinary Nature Conservation management and are able to evaluate sustainable resource management strategies.

Teaching and Learning Methods:
The module combines the lecture "Wildlife and Conservation Biology" with an accompanying practical exercise "Case Studies in Nature Conservation". The lecture contents will be presented using lectures based on power-point presentation and group work in order to combine activating teaching methods with classic presentation techniques. In the accompanying practical exercise, the students will apply the gained theoretical knowledge by conducting case studies (research programs), and presenting own concepts of research project in various content in the field of Wildlife Conservation Biology and Nature Conservation. Here the students learn to independently screen the respective literature in this field and learn methods in science communication.

Media:
Form of presentation: lecture, case study, movie segment and practical exercise material: lecture notes, flip-chart/board, plus different materials for methodological/technical training

Reading List:

Responsible for Module:
Kühn, Ralph; Apl. Prof. Dr. agr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Landscape Management | Landscape Management

Module Description

WZ4201: Vegetation Ecology and Geographical Information Systems | Vegetation Ecology and Geographical Information Systems

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
A written exam (Klausur) assesses whether the students understand the basic concepts of spatial data analysis as well as vegetation ecology with respect to manage landscapes, the students' ability to apply these techniques to certain problems in landscape management as well as the students' ability to precisely describe solutions to achieve certain results within a limited amount of time.
A voluntary Mid-Term assignment (presentation) assesses the students' ability to communicate management plans based on vegetation and habitat data. It will serve for grade improvement by 0,3 according to §6 (5) APSO.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in GIS, remote sensing, for example learned by attending the module "Inventory Methods and GIS". Basic knowledge of plant species.

Content:
1. Advanced analysis and visualization of spatial data;
2. GIS based raster analysis;
3. GIS and satellite navigation;
4. Application of GIS in selected projects;
5. Introduction to the vegetation ecology, theory of plant distribution and of plantcommunities;
6. Methods of habitat mapping;
7. Habitat mapping in the field;
7. Field data analysis;
8. Management measures for management plans.

**Intended Learning Outcomes:**
At the end of the module students are able to:
- manage, analyze and visualize spatial data to solve problems related to landscape management;
- break down general problems in landscape management to tasks which can be solved by using a GIS;
- develop and communicate management plans based on vegetation and habitat data;
- ascertain and classify habitats.

**Teaching and Learning Methods:**
Theoretical explanation of certain topics followed by practical exercises using GIS software supported by screen animations.
Transfer of theoretical knowledge in lectures (vegetation ecology, habitat mapping), practical field work and presentation of proposals for landscape management measures.

**Media:**
GIS Software, PowerPoint Presentation

**Reading List:**
To be announced

**Responsible for Module:**
Döllerer, Martin; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://www.tum.de).
Module Description

WZ2719: Landscape Planning | Landscape Planning

Version of module description: Gültig ab summerterm 2021

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The attainment of learning outcomes for the module will be assessed in a piece of research paper of around 10 pages in which students work independently on complex issues of contemporary landscape planning demonstrating their breadth of understanding in drawing out implications of their findings and putting them into a broader context. The written assignment is complemented by a presentation and/or a colloquium of around 30 min for assessing the capacity of the students to communicate their findings orally to an audience. Depending on the number of participants, research paper and accompanying talk may be prepared either individually or in groups.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic understanding of environmental systems; Module WZ2713 Methods of Scientific Communication. For the LP seminar, class discussion is a core element. Therefore, students are expected to take part and contribute to the discourse.

Content:
Concerned with the stewardship and enhancement of environmental systems, Landscape Planning is the key planning instrument for nature conservation and landscape management in Germany. The module introduces Landscape Planning and reflects on its potential contribution to sustainable land use with a focus on non-urban areas.

Course 1: Lectures will address the guiding principles, formal instruments and procedural elements of Landscape Planning; present methodological approaches for the assessment of landscape functions and ecosystem services including methods and tools for data collection, analysis and evaluation; illustrate target formulation and implementation strategies with examples from the planning practice.
Course 2: The seminar gives students the opportunity to deepen their knowledge by reflecting on readings and planning documents as well as by discussing in class such topics as: contemporary and emerging scientific theories and methodological approaches relevant for environmental planning; rationale of stakeholder involvement; context-dependency of spatial planning; comparison of current jurisdictional and institutional arrangements on landscape-related planning in the home countries of the students and their implications.

Intended Learning Outcomes:
Upon completion of the module, students are able to:
- recognize the purpose and objectives of Landscape Planning;
- explain instruments and procedural elements of contemporary Landscape Planning;
- select appropriate methods and tools to assess landscape functions and ecosystem services;
- be aware of the role of Landscape Planning in the decision-making upon the use of land;
- retrieve and interpret information from different sources;
- communicate key concepts relevant for environmental planning (both written and oral).

Teaching and Learning Methods:
Lectures provide subject specific knowledge; class discussions of selected readings engage students in critical thinking; in group work activities students experience the application of selected methods and tools.

Media:
Lectures, presentations, class discussions, small group exercises, assigned readings.

Reading List:

Responsible for Module:
Dr. Isabel Augenstein i.augenstein@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2737: Remote Sensing and Image Processing | Remote Sensing and Image Processing

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Achievements will be assessed by exercises, a presentation and a final report (project work). On behalf of home exercises the students get a first insight into concepts of image analysis. “Hands on” exercises with state of the art software packages are employed to train the main image processing steps and to assess the understanding of the students in implementing the basic concepts of remote sensing from data take to data analysis. Regular discussions with the tutor measure the student’s ability to develop an idea from initial concepts to the complete picture within a given timeframe, delivering interim results at relevant milestones (35%). On behalf of a presentation of a topic related to remote sensing the student’s ability to understand a technical/scientific subject, to analyze and evaluate facts and factors of influence, to summarize the subject and present it to an audience, and to conduct a discussion about the presented subject is assessed. With the final report the students demonstrate that they have gained deeper knowledge of the specific image analysis software packages and its components, of differing analysis concepts and that they are prepared to evaluate an existing situation as imaged by the respective remote sensing data set. They demonstrate further that they are able to create new geodata layers appropriated to be analyzed in an integrating GIS environment (65%). The grade weights of module examination components correspond to the weighting factors given in brackets.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Module "Inventory Methods and GIS" of the 1th semester of the Master Program "Sustainable Resource Management" passed, computer skills at least at working level.
Content:

Intended Learning Outcomes:
At the end of the Remote Sensing and Image Processing module (RSIP) the students are able to: - decide which data set is most appropriated to solve his thematic task, - access data bases, download and open a data set for image processing, - geocode/georeference digital data sets, - develop appropriated interpretation keys fitting the data set and the targeted thematic goal, - visualize and enhance the data set for interpretation, - extract spectral signatures, - calculate indices on behalf of the data, - learn how to extract bio-geo-chemo-physical parameter from the data set, - perform unsupervised and supervised classifications, - proof the quality of the results by an accuracy assessment, - perform a change detection study, - export the results as GIS layer.

Teaching and Learning Methods:
By using advanced image processing software packages the theoretical explained concepts are exercised “hands on” and discussed on basis of different data types applying the “just in time teaching (JiTT)” technique; the practical courses are prepared by homework (presentation of specific related topics, exercises); the short presentations will be given during the courses, contents, layout and style discussed and narrated; the home exercises explained in close relation to the computer exercises just done. The definition of the problem to be solved by image analysis techniques and the development of appropriated solutions needs research of reference materials. The final outcome of the courses, the classification result, will be used as basis for the Module “Application Study” of the concentration field “Landscape Management”.

Media:
Image processing software and tutorials, prepared exercises, different data types

Reading List:

**Responsible for Module:**
Dr. Thomas Schneider – Fachgebiet für Waldinventur und nachhaltige Nutzung
tomi.schneider@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Remote Sensing and Image Processing (Vorlesung, 6 SWS)
Mengesha M
For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://www.campus.tum.de).
Module Description

WZ4094: Landscape Management - Application Study

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>95</td>
<td>75</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment is based on a project work: 1. the participation intensity on discussions and the quality of the contributions during the courses; 2. the demonstrated skills in creating new data layers by combining existing data from official sources (administrations, organizations, etc.) using GIS techniques, in exploring new data and information layers (RS, vegetation ecology), etc. 3. the contribution in developing the project (planning competences); 4. the presentation style, contents and layout; 5. the team work; 6. the project report.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
The successful completion of the modules "Inventory Methods and GIS", "Remote Sensing and Image Processing", "Geographical Information Systems and Vegetation Ecology" and "Landscape Planning" or equivalent skills are required, courses on scientific writing and reporting recommended.

Content:
1. Implementation of GIS and RS techniques.
2. Implementation of theoretical concepts of Vegetation Ecology;
3. Implementation of theoretical concepts of Landscape Planning;
4. Oral presentation of findings;
5. Elaboration of a final report.

Intended Learning Outcomes:
At the end of the module the students are able to develop or at least to contribute to a landscape management project. More in detail the students are able to:
- work in a team;
- apply the theoretical and practical skills in vegetation ecology, landscape planning, remote sensing and GIS techniques;
- contribute to context-dependant landscape-related planning;
- deliver an oral presentation to communicate their findings;
- prepare a convincing project report using supporting data to back their statements in accordance with guidelines for scientific writing.

**Teaching and Learning Methods:**
Prime characteristic of the Application Study is the self-organized group work by the students to reach the defined objective of the project assignment. Progress of the team is supported by group discussions, theory input and coaching provided by lecturers on demand.

**Media:**
Scripts and reports of the above listed lectures and exercises offered within the elective field; basic data sets to develop the application study (GIS, RS, etc.); additional information on request and up on necessity (project driven).

**Reading List:**
The literature recommended within the Modules "Inventory Methods and GIS", "Remote Sensing and Image Processing", "Geographical Information Systems and Vegetation Ecology" and "Landscape Planning" should be used.

**Responsible for Module:**
Dr. Thomas Schneider – Professur für Waldinventur und nachhaltige Nutzung Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, 08161/ 71-4666; tomi.schneider@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Landscape Management - Application Study (Vorlesung mit integrierten Übungen, 5 SWS)
Augenstein I, Döllerer M, Mengesha M, Teixeira Pinto L
For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Renewable Resources | Renewable Resources

Module Description


Version of module description: Gültig ab summerterm 2017

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter/summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The grading is based on a research paper (max. 7.500 words). The students show that they are able to apply theoretical perspectives to the context of life sciences. Moreover, they develop an argument matching the concept of sustainable entrepreneurship as a promising approach for addressing complex sustainability issues in general and in the field of life sciences in particular. In the research paper students show that they can evaluate different approaches and develop their own ideas for life sciences-related sustainable ventures.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Courses in entrepreneurship, corporate sustainability and/or sustainability marketing are recommended.

Content:
Whether it is tackling climate change, resource degradation or social inequalities - responding to sustainability issues constitutes the biggest challenge for businesses in the 21st century. Embracing a great range of industries including food, energy or textiles, the field of life sciences is a key area for sustainability. Since the production of these goods accounts for an extensive use of resources, there is great potential for effecting real improvements on a way towards more sustainable production and lifestyles. The course "Advanced Seminar Life Sciences and Management" will investigate this exciting and ongoing industrial transformation. It will deal with
the following topics (all topics will be explained in general and then discussed in the context of life sciences in particular):

1) Introduction to Sustainability and Entrepreneurship
2) Sustainable Entrepreneurship
3) Opportunity Identification
4) Development of Double and Triple Bottom Line Solutions
5) Forming and Funding of New Sustainable Ventures
6) Market Entry
7) Sustainable Entrepreneurship and Life Sciences - Reflections and Discussion

Intended Learning Outcomes:
Upon successful completion of this module, students will be able to (1) summarize and (2) evaluate the socio-economic problems society is facing. They will (2) match the concept of sustainable entrepreneurship as a promising approach for addressing complex sustainability issues in general, and in the field of life sciences in particular. More specifically, students will (3) be able to identify the venture creation process from opportunity identification to market entry in the context of sustainability and life sciences. In addition, participants will be able to (4) apply this knowledge to the field of life sciences. Finally, the students will be able to (5) critically evaluate case studies from the field of life sciences and to (6) create own ideas for sustainable ventures in this context.

Teaching and Learning Methods:
The module is a seminar which intends to familiarize the student with the relevant literature and follows an interactive course format with group work assignments and guest lectures. This is the appropriate format for this advanced level module because it encourages the students to go into further detail and to deal with the issues in an integral, interactive and independent way.

Media:
Presentations, slides, cases, links and further literature will be provided via www.moodle.tum.de

Reading List:

The module is based on key scientific papers on each topic. These form the basis for classroom discussions and are to be used for developing an argument in the reflection essay. All articles are provided as pdf files in TUM Moodle (https://www.moodle.tum.de).

Responsible for Module:
Belz, Frank-Martin; Prof. Dr. oec.
Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Life Sciences, Management & Policy / Innovation & Entrepreneurship (WIB14002): Sustainable Entrepreneurship - Theoretical Foundations (Limited places) (Seminar, 4 SWS)
Belz F, Salvi E
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2720: Renewable Energy Technologies | Renewable Energy Technologies

Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a written test, where the students have to proof that they understand and remember the basic technical principles related to energy production and the working principles of the presented renewable energy technologies, as well as the related ecological and economical properties and frame conditions. The students have to answer questions, but may also be asked to do calculations, complete figures or prepare sketches.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
General understanding of natural science, mathematics and basics of technology.

Content:
The course provides an overview of the basics of thermodynamics and the principles of energy conversion. Energy conversion and its importance for the economy is discussed. Because of their transitional character due to the German “Energiewende”, the course focusses on the European and German energy systems. The international students in the course are expected to support the lecture with their experiences from abroad.

Basic technical principles of energy production, efficiencies, costs and environmental impacts will be understood. The focus lies on the following areas: solar, wind, water and geothermal energy conversion.

The course provides an overview of the basics of thermodynamics and the principles of energy conversion. Energy conversion and its importance for the economy is discussed. Because of their transitional character due to the German “Energiewende”, the course focusses on the European and German energy systems. The international students in the course are expected to support the lecture with their experiences from abroad.
Basic technical principles of energy production, efficiencies, costs and environmental impacts will be understood. The focus lies on the following areas: solar, wind, water and geothermal energy conversion.
In order to complete the picture, also storage and fossil fuel technologies will be discussed. The students will understand their role and their contribution to balancing energy production and demand.

**Intended Learning Outcomes:**
At the end of the course, the students understand the technical principles of renewable energy conversion systems.
They are able to interpret energy scenarios and solve simple problems associated with a high renewable energy share and its implications on society.
The students can estimate the importance of distinct technologies for a sustainable energy supply.

**Teaching and Learning Methods:**
Lecture with integrated exercises and teamwork, as well as discussions to improve understanding.

**Media:**
Power point presentation, black board, Videoclips

**Reading List:**
Tba

**Responsible for Module:**
Dr. Doris Schieder - Lehrstuhl für Chemie Biogener Rohstoffe doris.schieder@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Renewable Energy Technologies

Christoph Wieland, Doris Schieder, Annelies Vandersickel
For further information in this module, please click campus.tum.de or here.
Module Description

**WZ2721: Agriculture Raw Materials and their Utilization | Agriculture Raw Materials and their Utilization [ARM&U]**

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

**Description of Examination Method:**

The module grade is assessed by a written exam (60 min). The students show that they have understood the principles of biomass production for bioenergy use, biomass supply chains, and the different bioenergy systems. The written exam demonstrates the student's ability to deal with questions, and calculations, complete figures or prepare sketches in regard to biomass production for bioenergy use.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

General understanding of natural science, mathematics and basics of technology.

**Content:**

The targets for the module “Agriculture Raw Materials and their Utilization” are impart a basic understanding of the possibilities and limitations for the agricultural production of biomass for energetic and industrial uses and to provide an overview of ecological impacts of diverse biomass and bioenergy utilization pathways.

The module comprises a lecture which deals with the following topics:
- Production of agricultural biomass and the most important energy and industry crops
- Biomass chains and uses
- Diverse bioenergy systems
- Bioeconomy & biorefineries (related to Agricultural products)

Ecological impact assessment of biomass and bioenergy utilization.
Intended Learning Outcomes:
At the end of the module students have acquired knowledge of the production and utilization of
renewable resources from the agricultural and forestry sector. They know how to analyze the performance and ecological impacts of different biomass supply and utilization chains. They can estimate the suitability of various crops for bioenergy use. The students have an insight in the physical and chemical basics of energy production from biomass and are able to apply related basic equations. They can compare different biomass combustion systems and attribute emissions. The students know the production pathways and properties of different biofuels for transportation and are able to estimate their future potentials. They understand the technological background of biogas production and can do basic designs of biomass supply and utilization chains using the example of biogas systems in agriculture.

Teaching and Learning Methods:
The lecture with integrated exercises and discussions will improve the understanding. During the lecture a power point presentation related to the lecture topics will be done from each student to improve the discussion in the different topics of the module.

Media:
Power point presentations, black board. Videos, Online Quiz.

Reading List:

Responsible for Module:
Hijazi, Omar; Dr. rer. agr.

Courses (Type of course, Weekly hours per semester), Instructor:
Agriculture Raw Materials and their Utilization (Vorlesung, 4 SWS)
Hijazi O

For further information in this module, please click campus.tum.de or here.
Module Description

WZ4098: Forestry Raw Materials and their Utilization | Forestry Raw Materials and their Utilization

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning success will be assessed by a written examination (duration 60 min) where students are expected to demonstrate the level of knowledge and their ability to use and apply it in solution finding strategies. Additionally a midterm Assignment (voluntarily), the students have to prepare and give a structured oral presentation in a seminar organized at the end of the summer term. The topic of the presentation is defined in agreement with the lecturer. The presentation may be prepared either individually or in groups of two. The midterm presentation Assignment allows to improve the examination mark by 0.3.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basics of biology, chemistry, physics and sciences to deal with the biological production, and the processing and conversion processes of wood to final products, and the environmental assessment.

Content:
1. Overview and global potential of forest resources;
2. Availability, characteristics and properties of forest based products (wood and non-timber forest products);
3. Technologies and processes from raw materials to final products: sawn timber, wood-based products, pulp and paper;
4. Criteria and rules of a resource efficient application;
5. Environmental assessment of forestry raw materials and products.
Intended Learning Outcomes:
Upon successful completion of the module students are able to:
- illustrate the multidisciplinary of forests and their products;
- propose options to maximize the value chains of forest based products;
- exemplify production and process technologies and typical sector industries;
- demonstrate the role, potential and limitations of forestry raw materials in the framework of sustainable development;
- outline economical, environmental and social aspects of typical products and applications;
- develop strategies to strengthen the value and impact of typical forestry raw materials and non-timber forest products.

Teaching and Learning Methods:
Lecture, exercises, seminar, Optional: visits to laboratories and industry.

Media:
Demonstration material: raw materials and products; PP presentations; videos.

Reading List:

Responsible for Module:
Prof. Dr. Klaus Richter – Lehrstuhl für Holzwissenschaft  Winzererstr. 45, 80797 München, Tel.: 089/ 2180 - 6421, richter@hfm.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
For further information in this module, please click campus.tum.de or here.
Module Description

WZ4202: Political and Social Perspectives of Renewable Resources | Political and Social Perspectives of Renewable Resources

Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>105</td>
<td>45</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Oral presentation of the group project work, review paper for a scientific journal. The learning outcomes are assessed by a group project work concerning a selected topic related to the political and social perspectives of renewable resources. Therefore students have to prepare a scientific paper for an international journal of their choice and give a short oral presentation about the work done for the paper, similar to what would be expected in a 15 minute conference presentation.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of sustainable resources (materials and energy). Scientific writing.

Content:
In the lectures a number of examples of societal aspects of Sustainable Resource programs will be presented and discussed. Backgrounds are global developments such as urbanization, the rise of countries like China and India, resource availability and technological developments. Case studies deal with tropical forestry and pros and cons of tropical hardwood uses, urban planning, vernacular architecture and the use of renewable resources. We take a tour around the world and look at social housing programs in Europe, Brazil and South-East Asia. Furthermore we look at successes and failures in the German/European energy policies in comparison to the United States.

Intended Learning Outcomes:
After this course, students should be able to:
1. Develop SR stimulation programs on country or regional level and priority analysis of renewable resource applications
2. Assess priorities for development and application of renewable resources in countries with different levels of development
3. Critically analyze existing SR programs taking into account social values of stakeholders,
4. Assess impacts of global developments such as urbanization and UN-policies on SR.

Teaching and Learning Methods:
Discussion and creativity sessions. Project work evolving in a scientific paper for a journal of choice. Oral presentation.

Media:
Lectures, UN-policy notes, Discussion and Creativity sessions.

Reading List:
Tba

Responsible for Module:
van de Kuilen, Jan Willem; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Political and Social Perspectives of Renewable Resources (Vorlesung, 4 SWS)
van de Kuilen J [L], van de Kuilen J, Khaloian Sarnaghi A
For further information in this module, please click campus.tum.de or here.
Module Description

El70860: Integration of Renewable Energies | Integration of Renewable Energies [IRE]

Version of module description: Gültig ab summerterm 2020

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>German/English</td>
<td>one semester</td>
<td>winter/summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module exam consists of a written exam (60 min). The goal of the exam is to test if the students are able to reproduce general challenges regarding the integration of renewable energies. With calculations on simple examples the capability of working with this general knowledge on specific questions is tested. The exam will be graded.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamental knowledge in:
- renewable energy technologies (hydro, wind, photovoltaic, biomass, geothermal)
- power generation and transportation in large quantities in future energy supply scenarios
- fossil and renewable energy carriers
- regulation frameworks in electricity markets
- political and social aspects in energy systems

Content:
The lecture is subdivided in an introduction and three main chapters (physical, system and market integration), which classify the different challenges of the integration of renewable energies in an existing electricity system:
The introduction discusses the characteristics of fluctuating power generation from renewable energies and derives the resulting challenges for the system.
Physical integration discusses (technical) options, which enable an adaption of the generation side and the demand side (grid, storage, demand side integration, etc.).
System integration evaluates the possible contribution of renewable energies to provide ancillary services (balancing power, reactive power, inertia, etc.).
Market integration explain the influence of an increasing share of renewables on the existing market participants and discusses alternative framework design options.

**Intended Learning Outcomes:**
Upon successful completion of the module, students are able to:
- describe the challenges of a power system with a high share of renewable energies
- understand the properties of renewable energies from a system perspective
- analyze possible options to improve the integration of the renewable energies
- understand the system behavior of renewable energies
- analyze the influence of renewable power generation on operation of the conventional power plant park
- assess renewable power generation in relation to electricity markets and the demand of balancing power

**Teaching and Learning Methods:**
Lecture: beamer and partly blackboard presentations with teacher centered teaching
Tutorials: Calculations (by hand or PC based) as well as reading assignments which are both discussed in lessons

Language of instruction, English in Winter Semester and German in Summer Semester.

**Media:**
Lecture and exercise with beamer and blackboard. Presentations and exercise will be presented online.

**Reading List:**
Lawrence E. Jones, Renewable Energy Integration, 2017
IEA: The Power of Transformation, 2014

**Responsible for Module:**
Hamacher, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Integration of Renewable Energies (Vorlesung mit integrierten Übungen, 4 SWS)
KuhnP, Gawlick J
For further information in this module, please click campus.tum.de or here.
Climate, Air and Water | Climate, Air and Water

Module Description

WZ2731: Hydrometeorology and Management of Water Resources | Hydrometeorology and Management of Water Resources

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcome will be assessed by an oral examination (30 min) in which students should demonstrate their profound understanding of water management and ability to analyze and evaluate key issues and challenges. They should exhibit the capability of identifying and solving problems in a concise way and show that they can express themselves in a clear and scientific manner. A voluntary mid-term assignment (presentation) in the seminar assesses the students' ability to communicate and present an integrated management study case in one selected topic in sustainable water management. It will serve for grade improvement by 0.3 according to §6(5) APSO.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in chemistry and physics.

Content:
1. Hydrometeorology (including hydrological cycles, precipitation-, run off-, evapotranspiration - process of formation, measurement, global and regional spatial and temporal patterns, influences by land use land cover change, climate change scientific basis, climate change impacts, adaptation, vulnerability in water resources).
2. Problems in water management according to too little water, too much or too dirty. Different aspects of water augmentation (e.g. harvesting, desalination, translocation), water conservation (irrigation, pricing, household, …), water management processes (e.g. IWRM, virtual water) are discussed by practical examples;
Intended Learning Outcomes:
Upon the successful completion of this module the students are able to understand the basics of hydrology, and the influence of climate change on hydrological processes and management. They are able to analyze and classify various problems in water resource management and to assess the suitability and applicability of different management practices in the field of water augmentation (e.g. rain water harvesting, fog nets, dams) and water saving strategies (e.g. in irrigation, sanitation) to integratively solve water-resource-problems.

Teaching and Learning Methods:
The basics of hydrology and meteorology are presented and discussed in a lecture with thorough explanations. Some simple case studies are used to introduce into the theoretical background (e.g. meteorological instruments at the meteorological platform). Student presentations and discussions, group work in the seminar.

Media:
PowerPoint presentations; Presentation notes supporting the lecture. Case studies.

Reading List:

Responsible for Module:
Prof. Dr. Annette Menzel - Professur für Ökoklimatologie Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, 08161/ 71-4740, amenzel@wzw.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2722: Mountain Catchments under Changing Climate | Mountain Catchments under Changing Climate

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a written exam, students demonstrate that they have gained an understanding of hydrological processes and that they are able to apply and run a hydrological model for a mountain catchment. By an 10min oral presentation and a 5min discussion via Live-Stream (ZOOM) the students’ ability to understand selected hydrology-related threats for mountain catchments and to scientifically analyze and evaluate important influencing factors, to present it to an audience, and to conduct a discussion about the presented subject in a clear and concise scientific manner is assessed. The final grade is an averaged grade from the presentation (65%) and the written exam (35%).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Introduction in Hydrometeorology and management of water resources.

Content:
In the Field Course Applied Hydrometeorology of Mountain Catchments we will visit selected research stations, field sites, hydrological infrastructure, restoration sites, and protected areas in the Munich PreAlpine and Alpine area and learn more about hydrology-related threats for mountain catchments ranging from Glacier melt to Munich's drinking water. Sites include e.g. Environmental Research Station Schneefernerhaus, KIT Alpine Campus Garmisch, Waldklimastation Kreuth, Sachenbach catchment, Versuchstation Obernach, Sylvensteinspeicher, Walchenseekraftwerk, Versuchsstation Wielenbach, Mangfall / Lech Wassereinzugsgebiet.
The Hydrological Modeling course includes:
1) Dominant hydrological processes in mountain catchments: Precipitation types, runoff generation, concentration and flood routing
2) Data in mountain catchments: Availability, quality, acquisition and analysis
3) Types of hydrological models
4) Generation, parameterization and calibration of the process based hydrological model WaSiM
5) Model sensitivity analyses with focus on meteorological input and land use scenarios.

**Intended Learning Outcomes:**
After completion of the module, the students understand the main processes in mountain catchments like runoff generation, runoff concentration and flood routing processes. Additionally, they are able to use a physically based hydrological model to simulate the rainfall runoff process in mountain catchments and its influencing parameters caused by the special circumstances of these regions in a widely realistic and transparent way. The students are able to generate event based scenarios as well as land use scenarios and understand recent hydrology-related threats for mountain catchments as well as the influence of climate change on hydrological processes and management in mountain areas. They remember suitable monitoring and risk prevention strategies and are able to analyze, evaluate and communicate (both oral and written) a specific case study or research questions related to the experimental sites visited to a general audience.

**Teaching and Learning Methods:**
Teaching methods include lecture as well as practical exercises at PC laboratory in respect to hydrological modelling, a week of field trip to Alpine and pre-alpine areas to the listed sites with guided tours by local scientists, administrators, TUM lectures as well as short presentations by the students.

**Media:**
PowerPoint Presentation, Hydrological model (e.g. WaSiM), Field work

**Reading List:**

**Responsible for Module:**
Responsible for Module: Prof. Dr. Annette Menzel - Professur für Ökoklimatologie Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, 08161/ 71-4740, menzel@wzw.tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2732: Environmental Monitoring and Data Analysis | Environmental Monitoring and Data Analysis

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Upon completion of the module, the students have a profound understanding of key aspects of environmental monitoring and are able to choose appropriate as well as to efficiently run environmental measurements, to reproducibly analyze acquired data and to clearly communicate results of environmental measurements.
This ability should be demonstrated by writing a research paper following standards of reproducible research based on different aspects of environmental monitoring and data analysis with R. For the research paper, either available data or data measured during the module should be used and be analyzed in respect to defined hypotheses; developed R code has to be provided too.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in R is recommended.

Content:
1 Environmental monitoring including principles, techniques and management issues used in environmental monitoring and assessment; Observing, recording, communicating and archiving collected data and providing it to project stakeholders in order to identify sustainable and responsible environmental practices.
Optional: short course Aerobiology, GAW program, visit of companies

2 Environmental data analysis
Introduction to data analysis with R; Principles of reproducible research and implementation with R; Pipelines for environmental data analysis from obtaining data via cleaning and transforming to modelling and visualization with modern R; Coverage of data retrieval from different storage
types for climate, proxy, phenology, and other data (text-based, netCDF, data bases); Modeling and visualization as complementary strategies for hypothesis-driven data analysis, based on published research from different fields of environmental sciences.

**Intended Learning Outcomes:**
After this module, the students can plan, implement and run environmental measurements. They are able to efficiently analyze environmental data sets, including download and import of data sets and visualization and modelling with R.

**Teaching and Learning Methods:**
Course 1 consists of a practical course in the laboratory and in the field where students will work in small teams on applied case studies and exercises related to environmental / meteorological monitoring. Course 2 then offers combined lecture and exercise sessions at the PC lab on how to efficiently analyze those environmental data sets of course 1.

**Media:**
PowerPoint Presentation, Field work, Interactive documents for data analysis

**Reading List:**
Beginner level tutorials for Swirl (http://swirlstats.com/)

**Responsible for Module:**
Responsible for Module: Prof. Dr. Annette Menzel - Professur für Ökoklimatologie Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, 08161/ 71-4740, menzel@wzw.tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Environmental monitoring and data analysis; ecological data analysis (Vorlesung mit integrierten Übungen, 3 SWS)
Menzel A [L], Buras A, Lüpke M

Environmental monitoring and data analysis; ecological monitoring (Vorlesung mit integrierten Übungen, 2 SWS)
Menzel A [L], Lüpke M

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2730: Climate Change - Science, Impacts and Adaptation, Mitigation | Climate Change - Science, Impacts and Adaptation, Mitigation

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Assessment consisting of oral examination (30 min) on the lecture and the seminar. In this oral examination the student is expected to demonstrate that he/she has understood the physical basis of the climate system and that they can identify the drivers of climate change. The student shows that he/she is able to apply his/her knowledge to develop adaptation and mitigation measures and to argue in discussions on climate change issues. A voluntary mid-term assignment (presentation) in the seminar assesses the students’ ability to summarize findings from scientific publications / case studies and to present them to an audience. The presentation is complemented by the preparation of a “PICO” that is presented on an interactive screen. The presentation will serve for grade improvement by 0.3 according to §6(5) APSO.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in meteorology, physics, biology.

Content:
Based on the newest IPCC report (AR 5) the theoretical background on the physical science basis of climate change, theory and practical application of adaptation and mitigation measures in biological, physical and chemical systems will be presented. In a related seminar, selected topics will be intensified in case studies. TUM as a NGO in the UNFCCC process offers an optional possibility also for students to take part in COP and related negotiations.

Intended Learning Outcomes:
After this module, the students can understand the physical basis of the climate system, identify all drivers of climate change and falsify common arguing of "climate sceptics". They can summarize
observed changes in the climate system as well as impacts in diverse systems and regions. They are able to assess cross-sectorial impacts of climate change in selected areas, to evaluate and develop adaptation and mitigation measures and strategies in biological, physical and chemical systems including an analysis of their effectiveness and cost-effectiveness.

**Teaching and Learning Methods:**
Lecture on physical basis of the climate system, impacts of climate change and important mitigation strategies. In the seminar group presentations of various topics regarding adaptation and mitigation of climate change will be presented as case studies. Optional excursion to UNFCCC meeting if applicable.

**Media:**
Lecture with PowerPoint Presentation, reader and exercises. Group work in seminar including problem driven case studies and student presentations, excursion.

**Reading List:**

**Responsible for Module:**
Rammig, Anja; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Ecological, social and economic aspects of CC impacts, adaptation and mitigation on different scales (Seminar, 2 SWS)
Estrella N [L], Menzel A, Estrella N

Climate Change - The complete briefing (Vorlesung, 2 SWS)
Rammig A [L], Buras A, Krause A

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2733: Introduction to Soil Science | Introduction to Soil Science

Version of module description: Gültig ab summerterm 2021

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a written exam of 60 minutes duration, the students demonstrate by answering questions without helping material their understanding of the nature and properties of soils, and they remember the characteristics of the soils of the field course as well the field assessment methods. In a pass/fail exam (laboratory assignment) in the field of 10 minutes duration, they prove their ability to survey and interpret a soil profile.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in chemistry, physics, and biology.

Content:
• What is a soil?
• Mineral (inorganic) soil components
• Soil biology and soil organic matter
• Soil chemistry
• Soil physics
• Soil-forming processes
• Soil survey
• Soil interpretation
• Soil erosion assessment

Intended Learning Outcomes:
The students understand the basics of soil science. They can use their knowledge from soil mineralogy, soil organic matter, soil chemistry, and soil physics to understand soil formation
processes and important biochemical and physical properties. The students are able to survey a soil profile and to detect the genesis of the surveyed soil. They can evaluate the possibilities of soil use, the risks to the soil itself and the risks to its environment. They are able to evaluate the hydrology of the soil and to judge the erosion risk.

**Teaching and Learning Methods:**
The lecture discusses the essentials of soil science. The field assessment starts with peer instructions to analyse a soil profile. During the course, the students will do more and more group work to train the evaluation of a soil profile, its hydrology and its erosion risks.

**Media:**
Lecture: presentation notes. Field Assessment: spade, auger, knife, colour charts, TDR probes, suction cups, erosion assessment kits.

**Reading List:**

**Responsible for Module:**
Schad, Peter; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://example.com).
Module Description

WZ2734: Soil Protection | Soil Protection

Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In an oral exam of 30 minutes duration, students demonstrate in a scientific discussion by answering questions without helping material their broad and deep understanding on how to protect soils. The understanding of soils, as achieved in the modules "Introduction to soil science" and "World soil resources", is implicitly part of the oral exam.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
The successful completion of the module "Introduction to Soil Science" or equivalent skills are required. The successful completion of the module "World Soil Resources" is recommended.

Content:
Principles of soil degradation, the world food problem, highly erodible soils, semi-arid environments (including irrigation and salinization problems), kaolinitic soils, shifting cultivation, organic and mineral fertilization, agroforestry, land use and greenhouse gases, soil functions, organic pollutants, inorganic pollutants (heavy metals), radionuclides, pesticides, pathways of pollutants, sorption, precipitation, co-precipitation, acidification, ways to assess the mobility of pollutants, remediation of brownfields.

Intended Learning Outcomes:
The students are able to apply their knowledge of soils, as achieved in the modules “Introduction to Soil Science” and “World Soil Resources”, to develop strategies of soil protection. They understand the major environmental factors that determine the food production in the world. They are able to address the specific problems of highly erodible soils, semi-arid land and kaolinitic soils and to design adequate land-use methods. The students understand the major factors that determine the fate of substances in soil. They are able to analyze and forecast the fate of heavy metals, organic
pollutants and radionuclides in soil and are familiar with important techniques for managing and remediating brownfields.

**Teaching and Learning Methods:**
Lecture, discussions

**Media:**
Presentation notes.

**Reading List:**

**Responsible for Module:**
Schad, Peter; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Bodenschutz - Organische und anorganische Schadstoffe in Böden (Vorlesung, 2 SWS)  
Bucka F

Soil Protection and World Food Production (Vorlesung, 2 SWS)  
Schad P

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2735: World Soil Resources | World Soil Resources

Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In an oral exam of 30 minutes duration, students demonstrate in a scientific discussion by answering questions without helping material their fundamental understanding of the soils of the world in relation to other ecological factors, and they remember the soils of the field course as well as the methods of surveying and classifying soils in the field. In a pass/fail exam (laboratory assignment) in the field of 10 minutes duration, they prove their ability to survey and classify soils of various landscapes and environmental settings. The understanding of soils, as achieved in the module "Introduction to soil science" is implicitly part of the oral exam.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
The successful participation at the module "Introduction to Soil Science" (which is given in the first half of the summer semester) is required.

Content:
• Soils of the world
• Chemical, biological and physical properties of soils
• Genesis of soils as the result of soil-forming processes
• Soil survey
• Soil classification according to the international system
• Soil interpretation.

Intended Learning Outcomes:
The students are able to apply their knowledge of soils, as achieved in the module “Introduction to Soil Science”, to all soils of the world. The students understand the characteristics of the soils of the world, the pattern of their geographical distribution, their genesis, their ecological potential and...
the threats to their functions. The students are able to survey a soil profile, to detect the genesis of the surveyed soil and to classify it according to the international soil classification system. They are able to evaluate the possibilities and risks of soil management. They can assess the relationship between the soil and its environmental setting.

Teaching and Learning Methods:
The lecture gives an overview of all soils of the world. The field course (several days) presents soils in a landscape outside southern Bavaria. The students are trained in the methodological skills of soil survey, soil classification and soil interpretation.

Media:
Lecture: presentation notes. Field Assessment: spade, auger, knife, colour charts.

Reading List:
Prepared by Schad, van Huyssteen, Micheli. FAO World Soil Resources Reports 106.

Responsible for Module:
Schad, Peter; Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Course 1:
World Soil Resources: Lecture
Course 2:
World Soil Resources: Field Course
Lecturer 1:
Dr. Peter Schad
Lecturer 2:
Dr. Peter Schad
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2736: Analytical Characterization of Soil Resources

Version of module description: Gültig ab summerterm 2021

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students hand in a research paper (10-15 pages), in which they present and discuss the analytical data obtained by own laboratory characterization of soil samples that were collected by the students themselves during a guided exercise in the field. The research paper is accompanied by an oral presentation (15-20 min) to assess the scientific communication skills of the students. For the final mark, the research paper accounts for 75% and the oral presentation for 25%.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
The successful completion of the module "Introduction to Soil Science" (WZ2733) or equivalent skills are required.

Content:
- Sampling and sample preparation
- Lab analyses: texture, density, water conductivity, organic and inorganic carbon, nitrogen, soil organic matter decomposition, pH, cation exchange capacity, Fe oxides, phosphate retention;
- Data interpretation

Intended Learning Outcomes:
The students are able to apply their knowledge of soils, as achieved in the module “Introduction to Soil Science”, to the most important physical, chemical and biological processes in soils. They are able to choose the adequate
laboratory method to answer a certain question on soil management. They know how to do sampling, sample preparation and laboratory work. They can interpret laboratory data and know, which conclusions can be made and which conclusions cannot be made. The students are able to communicate their results in a written and an oral manner.

**Teaching and Learning Methods:**
For every step, the lecturers give the theoretical background. Afterwards, every step is done by the students themselves, guided by the lecturers and the laboratory staff: sampling, analyses, data interpretation.

**Media:**
Lecture: presentation notes; sampling: field equipment; laboratory course: laboratory instruments

**Reading List:**
will be given in the course

**Responsible for Module:**
Schweizer, Steffen; Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Analytical characterization of soil resources: Laboratory course (Übung, 3 SWS)

Analytical characterization of soil resources: Lecture (Vorlesung, 1 SWS)
Schweizer S

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://campus.tum.de).
Material and Waste Management | Material and Waste Management

Module Description

WZ2724: Emission Control in Land-Use and Animal Husbandry | Emission Control in Land-Use and Animal Husbandry

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>105</td>
<td>45</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The oral examination will be held either as an individual or a group examination. If more than 40 students sign in for the examination the oral examination can be done in a written form (Klausur, 90 min). The duration of the oral examination is 20 min per person. The Students are able to describe typical agricultural production, the environmental impact and the measurement procedures to quantify and to qualify these impacts. On that basis they are able to weigh the advantages and disadvantages of possible measures of air pollution in agriculture.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Interest in the field of agriculture; willingness to learn about the causal relation between agriculture and emission control.

Content:
Upon completion of the module, students are able to understand and analyze:
- the principle of agriculture in plant and livestock production on a basic level
- the main emissions caused by agricultural processes on a deeper level
- interactions of agricultural processes with the emission
- the environmental effects of these emission
- the measurement procedures to qualify and quantify agricultural emissions
- possibilities of emission abatement in land-use and animal husbandry.
Intended Learning Outcomes:
At the end of the module students are able to:
- understand the interrelation between local causes and global impacts,
- apply the comprehension of basic physical, chemical, and biological principles to phenomena in practice,
- evaluate measurement techniques in a qualitative manner,
- evaluate measures and techniques of environment protection;
- understand the interrelation between animal husbandry and air pollution control,
- derive adequate measures of environmental protection.

Teaching and Learning Methods:
Lecture, practice course.

Media:
PowerPoint-slides, short clips.

Reading List:
Tba

Responsible for Module:
Dr. Stefan Neser – Bavarian State Research Center for Agriculture; Institute for Agricultural Engineering and Animal Husbandry; Voettinger Strasse 36, 85354 Freising, 0049 8161 713566; stefan.neser@lfl.bayern.de

Courses (Type of course, Weekly hours per semester), Instructor:
Emission control in Land-Use and Animal Husbandry (Vorlesung, 3 SWS)
Neser S
For further information in this module, please click campus.tum.de or here.
Module Description

WZ4206: Material Flow Management and Applications

Version of module description: Gültig ab winterterm 2018/19

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>105</td>
<td>45</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a research paper of around 12-15 pages which is the means to evaluate whether the students have understood and whether they are able to apply the methodology of material flow management on a case study in a scientifically manner and to create an own scientific paper about concepts for material flow management and treatment of materials based on the methodologies of material flow analysis and life cycle assessment. management and treatment of materials based on the methodologies of material flow analysis and life cycle assessment.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
knowledge in natural science (biology, chemistry, ecology, physics); understanding for engineering science and also for social/cultural aspects.

Content:
The students acquire detailed and differentiated knowledge about the following topics:
- need of material flow management
- procedure of material flow management
- material and substance flow analysis
- material flow assessment by sustainability indicators
- life cycle assessment
- development of strategies and measures for material flow management (e.g. resource efficiency, urban mining, industrial ecology, bio-economy, circular economy).
Intended Learning Outcomes:
By the means of the module the students are able to:
- understand the necessity of material flow management
- understand the relationships between different processes, technological treatments of materials and organizational measures
- apply the procedure of material and substance flow analysis
- apply the assessment methods of indicator systems and life cycle assessment
- create concepts for material flow management and treatment of materials.

Teaching and Learning Methods:
Concerning teaching methods, lecture and presentation parts provide the theoretical foundation of materials flow management. Real case studies are introduced to the students and worked out in the class. Likewise within interdisciplinary projects in reality, the students have to define and to solve problems collaboratively in group work by studying specialist literature and data sources. At the end they have to create a research paper as homework about this topic. The students are supervised by tutorials by the lecturer.

Media:
Power point presentation, lecture sheets, case studies of material and substance flow analysis and life cycle assessment.

Reading List:

Responsible for Module:
Prof. Dr. Gabriele Weber-Blaschke - Lehrstuhl für Holzwissenschaft Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising; 08161/71- 5635; weber-blaschke@hfm.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
For further information in this module, please click campus.tum.de or here.
Module Description

ED160017: Sustainable Manufacturing | Nachhaltige Produktion [SuM]

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>German/English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>105</td>
<td>45</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination is held as a written exam (90 min) in order to be able to check the learning outcomes achieved by means of short and comprehension questions as well as complex application examples and calculation tasks. A non-programmable calculator can be used as an aid. The students calculate, among other things, various technically and economically relevant sustainability variables and parameters on the basis of given practical examples. Thus the learning outcomes examined include basic aspects on awareness of the need for sustainable production, sustainability in the context of production, the holistic view of sustainability, manufacturing engineering measures, as well as assessment and measurement and standardisation of sustainability in production. In addition, the topics of sustainable design and use of products, energy and resource efficiency in production, social sustainability in production, data-based sustainability assessment in production and industrial circular economy are examined.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of the basics of production and related areas (logistics, product development, etc.) is recommended but not mandatory.

Content:
The module covers all relevant aspects regarding the topic “sustainable manufacturing” including a general overview, ways of assessing sustainability and methods to improve sustainability in an industrial context.
Lecture units:
• Sense of urgency: Why do we need to act now?
• Sustainability in the context of manufacturing
• Thinking sustainability holistically
• Manufacturing technology measures
• Evaluate, measure and standardize sustainability in manufacturing
• Sustainable design and use of products
• Energy and resource efficiency in production
• Social sustainability in production
• Data-based sustainability assessment for manufacturing
• Industrial circular economy

The module also includes exercise units, e.g. how to conduct an LCA, how to follow ISO 14001 for sustainability assessments, practical exercise on system thinking, group activity (develop suggestions for improvement of sustainability for an exemplary company).

Intended Learning Outcomes:
After attending the module, students can understand the importance of addressing the topic of sustainability, understand the fundamentals of sustainable manufacturing, evaluate the possible technical lever in a production that can be addressed to increase sustainability, analyze products regarding the potentials for being produced more sustainably, apply the concept of system thinking on sustainable manufacturing, and apply methods to measure sustainability.

Teaching and Learning Methods:
The module takes place in the form of a lecture and an exercise. In the lecture, the basics of sustainable production are explained using PowerPoint presentations. The basics of sustainable production are deepened by means of use cases, expert presentations and practical application examples. In this way, participants learn, for example, how to carry out a life cycle assessment, how to follow the standards of ISO 14001 for sustainability assessments, or how to use systems thinking to find solutions. The lecture is rounded off by guest lectures from industry in order to give students an insight into current industrial issues relating to sustainability in production.

In the exercise, the methods and concepts learned in the lecture are applied to concrete examples. The participants can create solution concepts directly with the exercise instructor and thus apply what they have learned directly to industrial or academic practical examples. They thus learn, for example, how energy and resource efficiency in production can be increased, how social sustainability in production can be integrated into production management, or which measures need to be taken for data-based sustainability assessment in production.

Media:
Presentations, Videos, Additional Literature

Reading List:
• DIN EN ISO 14040: Umweltmanagement – Ökobilanz – Grundsätze und Rahmenbedingungen
• DIN EN ISO 14001: Umweltmanagementsysteme – Anforderungen mit Anleitung zur Anwendung

**Responsible for Module:**
Zäh, Michael; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainable Manufacturing - Exercise (Übung, 1 SWS)
Zäh M, Paul M, Schneider D

Sustainable Manufacturing (Vorlesung, 2 SWS)
Zäh M, Paul M, Schneider D
For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description

WZ2723: Utilization and Treatment of Special Materials and Waste | Utilization and Treatment of Special Materials and Waste

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>120</td>
<td>30</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcome will be assessed by presentation (40 minutes per working group; about 10 minutes per person). The presentation will be complemented by a brief written precis. This assessment method is a good means to evaluate both whether the students are able to work self-reliantly on a topic and to present their significant results to an auditorium and whether they have understood their respective selected topic.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in natural science (biology, chemistry, ecology, physics) and engineering.

Content:
The students acquire detailed and differentiated knowledge about the following topics:

- Selected materials, products and production processes concerning high waste generation and heavy environmental problems
- Origin and types of the specific wastes,
- Classical disposal,
- Waste as a source of raw material,
- Utilization for products,
- Energetic utilization,
- Legal specification.

The special topics addressed depend on relevance, e.g. food and food waste, sewage sludge, e-waste or the like.
Intended Learning Outcomes:
By the means of the module the students are able:

- to describe the differences of special waste, e.g. food waste and selected municipal or industrial waste,
- to classify the amount and quality of special waste streams,
- to analyze problems concerning the special wastes,
- to develop treatment measures to handle the waste for avoiding or reducing impacts on the environment and human health,
- to transmit developed solutions to other waste and new products.

Teaching and Learning Methods:
The module consists of a lecture, providing the theoretical foundations, in combination with a seminar including feedback by the lecturers to the students’ work. The students have to define and to solve problems collaboratively in group work by studying specialist literature. At the end they have to prepare a presentation and a brief summary including problem statement and conclusions as homework under time constraint about this topic. The students are supervised by the lecturers.

Media:
PowerPoint Presentation

Reading List:
Additional literature depending on themes.

Responsible for Module:
Weber-Blaschke, Gabriele; Apl. Prof. Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Utilization and Treatment of Special Materials and Waste (Seminar, 2 SWS)
Weber-Blaschke G [L], Reh K
For further information in this module, please click campus.tum.de or here.
Module Description

BGU38014: Water and Wastewater Treatment Engineering | Wasserversorgung, Wasseraufbereitung und Abwasserbehandlung

Version of module description: Gültig ab summerterm 2020

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination of the module is a written exam of 120 minutes duration. Through theoretical questions students prove that they understand the individual stages for the elimination of wastewater constituents, the basics of water supply and wastewater management systems as well as necessity and feasibility of wastewater treatment methods, especially of municipal wastewater. Through calculation and design tasks, which are comprised of a treatment task with given input parameters, the students show that they can analyze resource management in the field of wastewater treatment, the performance of related systems, as well as location factors for water technology systems and can critically evaluate various conventional water and wastewater treatment techniques, taking into account urban and natural conditions. They also show that they are able to analyze water treatment problems in a limited time and apply the necessary procedures for the protection of public health, as well as to develop process optimization and solutions for municipal wastewater treatment considering technical and legal regulations.

The tasks often require own formulations, in some cases, multiple choice answers, the focus however being on short calculation tasks. In the exam, limited aids such as lecture handouts and personal notes are allowed. Not allowed are text books, internet and communication among themselves and with third parties.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Siedlungswasserwirtschaft Grundmodul (BGU38016)
Siedlungswasserwirtschaft Projektkurs (BGU38020)
Content:
1. Water supply resources and source protection; Character of raw water qualities
2. Regulatory and technical requirements for water and wastewater treatment; discharge standards
3. Processes to abstract, treat, store and distribute water for potable supply
4. Structure and organization of public water supply
5. Operation and maintenance of water treatment facilities
6. Character of wastewater, in particular municipal wastewater
7. Regulatory requirements and discharge standards
8. Approaches to treat municipal wastewater/resource recovery facilities
9. Fundamentals of biotechnology and microbial reactions/processes
10. Biological treatment processes
   a. Activated sludge processes (aerobic, anaerobic)
   b. Sequencing Batch Reactor (SBR) Technology
   c. Biofilm reactors
11. Disinfection (chlorine-based; UV irradiation)
12. Biosolids stabilization and energy recovery from waste streams

Intended Learning Outcomes:
After completion of this module course the students are able to:
- understand concepts of drinking water and wastewater treatment facilities and processes
- they will be able to apply the knowledge to select proper siting for drinking water facilities considering constraints within the urban and natural environment
- to analyze critical control points and evaluate the appropriate treatment unit processes to protect public health
- to create optimized treatment processes based on regulatory and technical requirements
- to understand the need and feasibility of wastewater treatment, with special emphasis on treatment of municipal wastewater
- to apply individual unit processes and operations to remove problematic constituents from wastewater using biological processes for organic and inorganic constituents as well as pathogens
- to analyze resource management related to wastewater treatment
- to design concepts for conventional processes for wastewater treatment and evaluate their performance.

Teaching and Learning Methods:
The module consists of a lecture with integrated exercises. In the lecture, the technical and legal requirements for water and wastewater treatment as well as the theoretical principles of mechanical and biological treatment methods are presented by means of presentations. Furthermore, holistic concepts for water and wastewater treatment are presented. On the basis of the lecture, the methods for water and wastewater treatment are worked into voluntary problem-solving exercises during class exercises and via the Moodle platform.

Media:
Powerpoint presentations; Exercises in class and as voluntary homework via classworks during the lecture and via Moodle
Reading List:
Metcalf & Eddy, Inc. (2003). Wastewater Engineering Treatment and Reuse
Fourth Edition by Metcalf & Eddy, Inc.

Responsible for Module:
Prof. Dr.-Ing. Jörg Drewes (jdrewes@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Water and Wastewater Treatment Engineering (Vorlesung mit integrierten Übungen, 4 SWS)
Drewes J [L], Drewes J
For further information in this module, please click campus.tum.de or here.
Module Description

WZ4207: Waste and Waste Water Treatment

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The written exam (90 min.) consists of general questions and simple calculations. In the written exam students demonstrate their theoretical knowledge of waste and wastewater treatment. The answers require wording but also single choice tests as well as calculations. Only the use of a calculator is allowed (closed book exam).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Interest and basic knowledge in chemistry, physics, biology and preferably in environmental, chemical, civil or process engineering. However, the level of the course is adapted to the known broad spectrum of background knowledge allowing also students to follow you hold a bachelor in a totally different realm.

Content:
Waste management:

1. Basics of waste management (What is waste, waste amounts, history and future of waste, waste legislation);
2. Avoidance and recovery of waste and waste management concepts;
3. Waste disposal (legal aspects of landfill, processes in above-ground landfill, above-ground landfill technologies, underground disposal sites);
4. Biological treatment (legal aspects, composting, fermentation, mechanical biological treatment, sewage sludge, substitute fuels);
5. Thermal treatment (legal aspect, thermal processes, equipment, power generation, alternative thermal processes, hazardous waste treatment).

Wastewater treatment:

1. Water treatment & management concepts; overview wastewater treatment steps
2. Wastewater characteristics & discharge limits
3. Mechanical wastewater treatment
4. Fundamentals in bioprocess technology; stoichiometry of biological reactions; kinetics of biological reactions; aeration
5. Biological wastewater treatment
6. Sewage sludge treatment
7. Field trip Garching wastewater treatment plant (optional)

Intended Learning Outcomes:
At the end of the module, students are able to:

1. Understand the necessity and objectives of waste management.
2. Understand the most important processes and technologies for waste treatment.
3. Decide which treatment method is valid for which type of waste.
4. Understand sources and types of emissions arising from waste treatment and measures for emission reduction

8. Understand the necessity and the feasibility of wastewater treatment especially in treating municipal wastewater.
9. Classify the single steps of eliminating wastewater compounds, such as coarse material, organic and inorganic pollutants.
10. Recall important treatment processes and their requirements.
11. Assess pros and cons of different treatment technologies.

Teaching and Learning Methods:
The knowledge in the field of waste management is imparted during lectures. Theoretical background is given and discussed at practical examples of existing waste management infrastructure (Collection Systems, Landfills, Treatment Facilities, etc.)

The content of the lecture are taught through practical examples. By means of example tasks in the lecture, possible solutions are discussed and exemplified calculations are performed. An optional field trip to the Garching wastewater treatment plant at the end of the course allows connecting theoretical knowledge with practical application and gives a final platform for questions.
Media:
The course is mainly taught by PowerPoint presentation and supported by notices on the black board. The lecture notes are uploaded to Moodle. It is ensured that further readings are available in the university library either for download or as hardcopy in an adequate number.

Reading List:
Waste Management:

Waste Management: https://issuu.com/tkverlag/docs/waste_management_4

Wastewater Treatment:

Responsible for Module:
Konrad Koch

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Sustainable Agricultural Value Chains | Sustainable Agricultural Value Chains

Module Description

WZ1876: Entrepreneurship in the Agricultural and Horticultural Industry | Entrepreneurship in the Agricultural and Horticultural Industry

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination consists of a 120-minute written exam. This will focus on testing the holistic understanding and competence with regard to the conceptual and metodoligical approaches in agri-food entrepreneurship.
In addition, students will analyze business start-up processes and risks in the innovation and product development process, assess entrepreneurial cooperations in the agricultural and horticultural sector, and design associated management and organizational structures.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamentals of Microeconomics, Market analysis

Content:
The module covers and discusses the principles, theoretical approaches and significance of entrepreneurship orientations to support the application of innovations and start-up related economic activities in the agricultural and horticultural value chains and industries. The course specifically includes the following topics:
- Principles of entrepreneurship and entrepreneurship orientations in the agricultural and horticultural industries.
- Innovation and product development processes and related entrepreneurial opportunities and risks
- Entrepreneurial strategies and collaborations in the venture creation process
- Methodological approaches (e.g. attribute mapping, strategy canvas and various business model and quantitative approaches) to explain and evaluate entrepreneurship-related activities and venture creation processes
- Sustainable entrepreneurship

**Intended Learning Outcomes:**
After successful completion of the module, students will be able to:
- understand the principles of entrepreneurship and business creation in the agricultural and horticultural sector,
- use qualitative and quantitative methods to explain and evaluate entrepreneurship related activities,
- analyze the risks and opportunities in innovation and product development,
- assess collaborations and strategies in entrepreneurship and business creation, and
- develop venture creation processes, associated management, and organizational structures.

**Teaching and Learning Methods:**
With the help of lectures, the theoretical approaches and concepts of entrepreneurship and the business start-up process are taught. Group work and presentations are used to describe and work on practical problems and proposed solutions.

**Media:**
Presentations, case descriptions, scripts

**Reading List:**

Die Liste wird anhand von weiteren thematisch relevanten Büchern, Zeitschriftenartikeln und aktuellen Themen aktualisiert

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or here.
Module Description

WZ1921: Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry | Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry

Version of module description: Gültig ab winterterm 2019/20

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment type for the module is a graded learning portfolio (100%). The portfolio includes memorandums addressing 9-10 of the case studies discussed in class; and a learning statement addressing conceptual, scientific and personal learning. Through the case memorandums, the students show the ability to discuss the assigned case questions by selecting and applying suitable theoretical concepts to supply chain management and sustainability challenges in the specific context of agribusiness and the food industry. In the learning statement, students demonstrate the ability to reflect on the semester long learning process and summarize the insights gained.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Solid economic and management background; knowledge of basic concepts of strategic analysis, planning, and management (e.g., industry analysis, horizontal and vertical coordination, and SWOT), as well as the ability to apply these concepts; furthermore, knowledge of value chain management is required (e.g., theoretical background, supply chain dynamics, actors and partnerships, governance). Successful completion of a management course on M.Sc. level required, e.g., agribusiness management or value chain management. Medium level experience in desk research and scientific writing is required.

Content:
The module builds on key concepts of supply chain management, strategy, and sustainability to provide master level students with the competency to evaluate pertinent issues in agribusiness and food industry supply chains. Topics covered include:
- value propositions, creating and capturing added value in agribusiness and the food industry
- management of customers, suppliers, and other stakeholders
- innovation in supply chains, sustainability as an innovation, sustainable supply chains
- CSR (corporate social responsibility) and sustainability measurement
- implementation of a sustainability strategy, as well as costs and benefits of sustainable practices in agribusiness and the food industry
- ethical issues in supply chain management.

**Intended Learning Outcomes:**
After successfully completing of the module, students are able to evaluate processes of supply chains management in agribusiness and the food industry. Specifically, students are able to
- evaluate value propositions, as well as plans for creating and capturing value
- evaluate the management of customers, suppliers, and other stakeholders
- independently choose scientific models or concepts relevant to the analysis process of agricultural and food industry supply chains and justify their choice
- evaluate the implementation of a CSR concept or sustainability strategy, and monitor its effects on operations, suppliers, associates, and customers
- identify and analyze ethical issues in supply chain management and to recommend how to apply ethical practices.

**Teaching and Learning Methods:**
The course Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry has a seminar format based on the case study method. The seminar format is implemented based on case descriptions of problems, challenges, and innovations in agribusiness and food industry supply chains. Through individually prepared class discussions and group work, students develop the ability to critically reflect and apply concepts of strategy, supply and value chain management, and sustainability requirements in the context of agribusiness and the food industry. During class discussions and group presentations, students reflect on their experiences, prior knowledge, and assignments to develop an in-depth understanding of current challenges in supply chains and how to address the.

**Media:**
Reading assignments; case descriptions; presentation software; discussion facilitation support media, such as flipcharts and discussion boards; video clips and podcasts.

**Reading List:**
Current articles from scientific journals as appropriate.
Selected chapters from
Pullmann and Wu (2011): Food Supply Chain Management: Economic, Social and Environmental Perspectives. Routledge, New York, US.
Responsible for Module:
Bitsch, Vera; Prof. Dr. Dr. h.c.

Courses (Type of course, Weekly hours per semester), Instructor:
Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry
(Seminar, 4 SWS)
Bitsch V [L], Köksal S, Huhn C, Carlson L
For further information in this module, please click campus.tum.de or here.
Module Description


Version of module description: Gültig ab summerterm 2019

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment type for the module is a graded report (10 pages). The report includes three sections: (1) critical analysis of a published empirical sustainability study in the context of its sustainability definitions and authors’ backgrounds; (2) critical analysis of a sustainability measurement system in use with regard to fulfilling requirements to be met by indicators and indicator systems; (3) critical analysis of a public sustainability claim by an organization from a consumer or citizen point of view. Each analysis is also presented by each student. Through reports, the students demonstrate the ability to understand relevant research, measurement systems and claims, as well as critically analyze and discuss these issues. Through the presentation and discussion of each analysis, students demonstrate their ability to communicate these critical issues and further reflect on each topic in the light of other students’ questions and presentations.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge and understanding of economic and management concepts as well as of social science research methods is required.

Content:
The development of a differentiated understanding of sustainability requires the critical analysis and reflection of sustainability concepts on multiple levels. In the module the following levels are systematically analyzed and discussed based on guided discussions of assigned readings and materials developed by students based on literature and internet research:
- Paradigms and value judgments in research on and evaluation of sustainability;
- Economic, environmental and social aspects of sustainable production, marketing, and consumption;
- Measurement systems for sustainability on different levels (products, supply chains etc.);
- Public and private standards, sustainability certifications and communication;
- Consequences of measurement systems and their foci, e.g., on environmental aspects, such as carbon footprint, or on social aspects, such as fair trade

These topics are discussed in the context to current and controversial issues regarding sustainability in science and in society.

**Intended Learning Outcomes:**
After successfully completing the module students are able to
- Analyze and evaluate the consequences of different paradigms on the definition and understanding of sustainability and its use in published scientific articles;
- Analyze and evaluate sustainability measurement systems on the product, enterprise, and supply chain levels as well as their potential consequences;
- Evaluate public sustainability claims based on the research of available information sources;
- Apply a differentiated understanding of sustainability in an interrelated, globalized context with differing value systems and priorities in scientific and practical questions and issues.

**Teaching and Learning Methods:**
The course “Sustainability: Paradigms, Indicators, and Measurement Systems” has a seminar format based on assigned readings and student presentations on assigned topic areas.
After an introductory guided class discussion on assumptions and implicit sustainability definitions of participants, readings are assigned and discussed in class to lay the basis for later student presentations. Through individual document research and individually prepared class presentations, students develop the ability to critically reflect on sustainability research, sustainability indicators and measurement systems, as well as sustainability claims by various actors and organizations. Through presentations and concept discussions, students develop in-depth knowledge of sustainability issues and hone their critical thinking skills. A final discussion summaries students’ learning and additional findings throughout the semester in the concept of wicked problems.

**Media:**
Reading assignments; use of data bases for literature research; presentation software; discussion facilitation support media, such as flipcharts and discussion boards; video clips and podcasts.

**Reading List:**
Current articles on sustainability paradigms, requirements of sustainability indicators and indicator systems, and applications.

**Responsible for Module:**
Courses (Type of course, Weekly hours per semester), Instructor:
Sustainability: Paradigms, Indicators, and Measurement Systems (Seminar, 4 SWS)
Bitsch V [L], Bitsch V, Carlson L
For further information in this module, please click campus.tum.de or here.
Module Description

WI001190: Cooperation and Integration in Agribusiness | Cooperation and Integration in Agribusiness

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module assessment will be in the form of 120-minuten written exam. In the exam, students should demonstrate that they understand the theoretical concepts and apply relevant analytical methods to solve problems. In addition, the students should prove that they can analyze practical problems, assess the various forms of cooperation and networks in agribusiness, and develop appropriate solutions for strategic cooperation and integration.

Repeat Examination:

(Recommended) Prerequisites:
Basics of sustainability and organizational collaboration

Content:
The module deals with the complex forms and approaches of cooperation and integration in agribusiness in order to improve the performances of agricultural enterprises. Specific topics of the module are:
• Theoretical approaches and basics of cooperation and integration with a focus on the concept of institutional economics (resource-based theory, transaction cost economics, contract theory, principal-agent approach, value chain governance and interventions including certification programs)
• Strategic options of horizontal and vertical integrations
• Forms of customer, business relationship and stakeholder management
• "Lean Management" and corporate collaborations
• Sustainability in the agri-food value chain and entrepreneurial activities
**Intended Learning Outcomes:**
Upon completion of the module, students will be able to:
• understand collaboration dynamics, challenges and problems as well as related solutions,
• use relevant qualitative and quantitative methods to analyze and improve business collaborations within the value chain,
• analyze and evaluate agribusiness related horizontal and vertical integrations,
• develop and design strategies for effective agri-food entrepreneurial collaborations and integrations.

**Teaching and Learning Methods:**
Lecture with integrated individual exercises, group work and case study analysis. 
The lecture is used to teach the theoretical concepts and approaches. Individual assignments, group work and case studies are used to work on specific empirical problems and to find solutions. This also includes learning through literature analysis.

**Media:**
Presentations (power points), case analysis formats and scripts

**Reading List:**
Fischer, F., et al. (2010), Factors influencing contractual choice and sustainable relationships in European agri-food supply chains. European Review of Agricultural Economics, 36(4): 541-569


The list will be expanded and updated using other thematically relevant books, journal articles and periodical newsletters and others.

**Responsible for Module:**
Sauer, Johannes; Prof. Dr. agr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Cooperation and Integration in Agribusiness (WI001190) (Vorlesung, 4 SWS)
Abate Kassa G [L], Abate Kassa G

For further information in this module, please click campus.tum.de or here.
Module Description

WI001215: Network and stakeholder analysis: Sustainable resource use and agri-food system | Network and stakeholder analysis: Sustainable resource use and agri-food system

Version of module description: Gültig ab winterterm 2019/20

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
There will be a 120-minute written exam. A written exam is necessary in order to assess the holistic understanding and analytical competencies of the students. In the exam, students will describe, discuss and analyze the concepts, dimensions and methodological approaches related to network and stakeholders in sustainable resource management and agri-food sector.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in cooperation and sustainability

Content:
The module deals with the theoretical concepts, methodologies and measurement indicators and approaches of networks and stakeholders for sustainable resource management and agri-food system. Specific topics include the following:

- Network and stakeholder theories and concepts to understand, describe and explain the structure, characteristics, interactions among networks and stakeholders

- Concepts and approaches to examine network and stakeholder compositions, engagements, conflicts and influences in designing and implementing strategic decisions related to sustainable innovation, resource management and agri-food system.

- Types, levels and extents of risk associated with stakeholder engagement in implementing sustainability related projects and programs
• Specific methodological approaches, tools and indicators to evaluate and prioritize the performances, outcomes and implications of different network and stakeholder constellations.

• Other relevant current network and stakeholder issues in sustainable innovation, resource management and agri-food system.

**Intended Learning Outcomes:**

After completing the module, students are able to

• understand the theories, concepts, principles and frameworks underlying network and stakeholder issues, influences and collaborations for sustainable innovation, resource management and agri-food system

• apply relevant techniques and tools for describing social, economic, environmental and institutional contexts of network and stakeholder management and engagement policies and strategies towards achieving specific sustainable goals.

• analyze types, levels and extent of risks associated with stakeholder engagement and commitment in implementing sustainability related projects and programs

• critically assess and evaluate the structure, characteristics, and impacts of various forms of networks and stakeholder groups on the outcomes of sustainable resource management, innovation and agri-food system.

**Teaching and Learning Methods:**

The module includes lectures, individual and group exercises, reading assignments, and presentations. The lectures will provide theoretical and conceptual basis. Individual and team exercises will be used to analyze and discuss specific network and stakeholder issues and their solutions.

**Media:**

Präsentationen, Fallbeschreibungen, Skripte

**Reading List:**


The list will be expanded and updated using other thematically relevant books, journal articles and periodical newsletters and others.

**Responsible for Module:**
Abate Kassa, Getachew; Dr. rer. hort.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or here.
Free Elective Modules | Free Elective Modules

Module Description

BGU38019: Anaerobic Processes and Energy Recovery |
Anaerobtechnik und Energierückgewinnung

Version of module description: Gültig ab winterterm 2018/19

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>90</td>
<td>60</td>
<td>30</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The proof of performance is made in the form of a 60-minute written exam with questions on the fundamental understanding as well as small calculation tasks. The aim of the written exam is the proof that the basic approaches in the field of energy recovery from urban waste streams were understood and different methods can be applied comparatively. Problems need to be analyzed and based on learning outcomes acquired in the course, students have to find and implement solutions in limited time. In the theoretical part, comprehension questions must be answered to basics of anaerobic technology and energy recovery from waste streams. In the calculating part, diverse issues should be analyzed and calculated based on the learning outcomes acquired during the module. The answers require partly own formulations, partly ticking given single or multiple answers. The focus is on short calculation tasks. For the exam no aids are permitted except for a non-programmable calculator.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Water and Wastewater Treatment Engineering (BGU38014)

Content:
• Basics of anaerobic digestion
• Co-digestion
• Power to gas
• Treatment of sewage sludge
Intended Learning Outcomes:
After the successful participation in the course, the students will be able to:
• remember the basic process concepts,
• analyze and evaluate the advantages and disadvantages of the different methods for the specific application,
• and develop simple approaches to calculate and dimension treatment schemes.

Teaching and Learning Methods:
The contents of the lecture are taught through practical examples. By means of example tasks in the lecture, possible solutions are discussed and exemplified calculations are performed. During exercise included in the lecture, students apply what they have learned on similar tasks and internalize the approach. The self-study is supported by the provision of further literature in Moodle.

Media:
Beamer, black board, literature provided

Reading List:

Responsible for Module:
Dr.-Ing. Konrad Koch, k.koch@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Module Description

CS0126: Advanced Seminar in Circular Economy and Sustainability Management | Advanced Seminar in Circular Economy and Sustainability Management [ASCESM]

Version of module description: Gültig ab summerterm 2021

<table>
<thead>
<tr>
<th>Module Level: Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
<th>Frequency: winter/summer semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits:* 7</td>
<td>Total Hours: 210</td>
<td>Self-study Hours: 150</td>
<td>Contact Hours: 60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
"Term paper and presentation: Students have to write a scientific paper on the given topic (15-20 pages). In doing so they have to show that they are capable to find relevant literature, structure a problem, solve it, and document the results of the process in a scientific paper. In the 30 minute final presentation they have to to show that they are able to summarize their findings in a scientific presentation, discuss and defend them (20' for presentation, 10' for discussion).
Weighting: Term paper 2, Presentation 1"

Repeat Examination:
Next semester

(Recommended) Prerequisites:
-

Content:
"The module deals with actual topics from Circular Economy and Sustainability Management. These differ from semester to semester. Topics will be announced at the end of the preceeding semester.

Intended Learning Outcomes:
The seminar aims at enabling students for scientific work. After passing the module the sutdents are able to find, structure and analyse relevant literature, solve the problem scientifically, discuss the solution critically, summarize the work in a term paper, hold a scientific presentation, and discuss and defend their work. Thereby the students acquire in-depht knowledge on a current topic from the thematic field of circular economy and sustainability management."
Teaching and Learning Methods:
Seminar: after an introduction on the topic the students carry out a literature research, structure the problem, identify solution approaches, apply these. They summarize their findings in a term paper and a scientific presentation. In this process they are supervised, receive materials, thematic introductions, advise in scientific work and continuous feedback in the seminar sessions. The seminar closes with a final presentation.

Teaching / learning methods:
- Kick-off session: media-assisted presentation
- Individual work and feedback
- Interim presentations / workshops
- Final presentation
- Computer lab exercises using LCA software systems and Life Cycle Inventory Data bases.

Media:
Digital projector, board, flipchart, online contents, recent scientific journal publications, computer lab

Reading List:
Recommended reading:
• Gastel B; Day R A (2017): How to write and publish a scientific paper, Cambridge University Press
• Skern T (2011): Writing Scientific English: A Workbook, UTB

Topic related reading, especially articles in international peer reviewed journals, will be provided in the kick-off meeting of the module.

Responsible for Module:
Magnus Fröhling

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Module Description


Version of module description: Gültig ab summerterm 2021

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

**Description of Examination Method:**

The module assessment is based on participation in group discussions, written critical reflections, and practical work assignments that demonstrate conceptual and applied understanding of course goals.

In addition, there is the possibility to submit a voluntary Mid-Term-Assessment (after APSO §6, Abs.5). For this assessment, students submit exercises, consisting of 3 assignments that were completed through the weekly exercises (e.g. data collection or analysis activity). Students should submit this on Moodle. By passing this coursework students can improve their module grade up to 0.3. For the Mid-Term-Assessment, no repetition date is offered. In case of a repetition of the module examination, a previously completed Mid-Term-Assessment will be taken into account.

The examination performance is given in the form of a research paper. The research paper will include a written research proposal (3-5 pages; 80% of grade) complemented by an oral presentation (15 min. + 5 min. discussion; 20% of grade). In the research proposal, each student will develop a research question, hypothesis(es), and experimental protocol to answer their question. Students should situate their research proposal in a theoretical framework, and propose fitting methods to examine their research question. Students will search for and synthesize relevant literature to justify their experimental choices. The final written research proposal will be the culmination of this project and will take the form of a research grant proposal. Students will comply with the same proposal guidelines and rules that graduate (PhD) students must follow when they apply for funding from e.g., Deutsche Bundesstiftung Umwelt (https://www.dbu.de/stipendien_promotion). Written summaries measure each student's understanding and evaluation of environmental/ecological and social concepts, and ability to apply theoretical frameworks and appropriate methods. In the presentation, the students present their research proposal (PowerPoint plus any additional aides) to demonstrate understanding of a research gap in
urban ecosystems, communicative competence, presentation and discussion skills in front of an audience.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
Basic knowledge in ecology and landscape ecology; beneficial to have completed the module(s) “Urban Ecology” WZ6407.

Content:
Urban areas are major drivers of global environmental change, habitat degradation, changes in biodiversity, and the loss of vegetation biomass. These and many other factors emphasize the necessity to understand and examine how urbanization affects the interactions between humans, greenspaces, wildlife and the built environment. Furthermore, it opens questions around the possibilities for urban habitats and landscapes to support the enhancement of biodiversity, energy conservation, food security, public health and well-being.

This module explores the ecology and planning of urban areas and landscapes. We will discuss advanced concepts in urban ecology including: altered dispersal and colonization dynamics of urban plant and animal communities; effects of environmental stressors on plant and animal traits and their interactions; soil and substrate heterogeneity in community dynamics, ecosystem structure and function; water and energy flows in urban food production; changes in cultural ecosystem services and human values; and the spatial analysis of dynamic urban land use. The students will utilize methodological approaches in urban ecology research including collecting and analyzing biodiversity data, structure and functions of greenspaces data, analyzing remotely sensed spatial data, and harnessing citizen science and social media data.

We will emphasize the importance of understanding and analyzing how dynamic ecological and social forces shape urban ecosystems and the provision of ecosystem services. The module will benefit students interested in urban ecology and conservation science, and those interested in urban planning and urban environmental management.

Intended Learning Outcomes:
On successful completion of the module, students are able to:
1. conceptually understand urban ecosystem dynamics, specifically the changes and the processes that underly ecosystem dynamics;
2. critically analyze the effects of environmental disturbances on urban ecosystem energy and nutrient flows, biodiversity, regeneration processes and the potential to deliver ecosystem services;
3. apply methods in the field and lab to measure and evaluate processes within terrestrial and aquatic urban systems, but also within social systems to analyze human perceptions and values underlying cultural services;
4. communicate critical insights into the potential consequences of ecological engineering strategies applied to managing different urban ecosystems and landscapes;
5. develop a research proposal to investigate novel questions in urban ecology and urban planning.

Teaching and Learning Methods:
The interactive module comprises a seminar (S) and an exercise (UE) / excursion (EX) to best combine lectures, case study analyses, group discussions, and presentations from guests and peers. The seminars will cover advanced concepts in lecture PowerPoint presentations but also through paper discussions and group work (3-5 students) on a range of topics (see above). Paired with a weekly topic, the exercises/excursions cover research methods that are based in experiential learning with foreseen excursions to field sites in Munich as well as laboratory work at TUM-WZW. Through field excursions and lab practical work, students will collect and analyze data to gain important methodological skills in conducting urban ecosystem and planning research.

Media:
PowerPoint, films, virtual lectures, virtual activities, data scripts

Reading List:

Responsible for Module:
Egerer, Monika; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2721: Agriculture Raw Materials and their Utilization | Agriculture Raw Materials and their Utilization [ARM&U]

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module grade is assessed by a written exam (60 min). The students show that they have understood the principles of biomass production for bioenergy use, biomass supply chains, and the different bioenergy systems. The written exam demonstrates the student's ability to deal with questions, and calculations, complete figures or prepare sketches in regard to biomass production for bioenergy use.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
General understanding of natural science, mathematics and basics of technology.

Content:
The targets for the module “Agriculture Raw Materials and their Utilization” are impart a basic understanding of the possibilities and limitations for the agricultural production of biomass for energetic and industrial uses and to provide an overview of ecological impacts of diverse biomass and bioenergy utilization pathways.
The module comprises a lecture which deals with the following topics:
- Production of agricultural biomass and the most important energy and industry crops
- Biomass chains and uses
- Diverse bioenergy systems
- Bioeconomy & biorefineries (related to Agricultural products)
Ecological impact assessment of biomass and bioenergy utilization.
Intended Learning Outcomes:
At the end of the module students have acquired knowledge of the production and utilization of renewable resources from the agricultural and forestry sector. They know how to analyze the performance and ecological impacts of different biomass supply and utilization chains. They can estimate the suitability of various crops for bioenergy use. The students have an insight in the physical and chemical basics of energy production from biomass and are able to apply related basic equations. They can compare different biomass combustion systems and attribute emissions. The students know the production pathways and properties of different biofuels for transportation and are able to estimate their future potentials. They understand the technological background of biogas production and can do basic designs of biomass supply and utilization chains using the example of biogas systems in agriculture.

Teaching and Learning Methods:
The lecture with integrated exercises and discussions will improve the understanding. During the lecture a power point presentation related to the lecture topics will be done from each student to improve the discussion in the different topics of the module.

Media:
Power point presentations, black board. Videos, Online Quiz.

Reading List:

Responsible for Module:
Hijazi, Omar; Dr. rer. agr.

Courses (Type of course, Weekly hours per semester), Instructor:
Agriculture Raw Materials and their Utilization (Vorlesung, 4 SWS)
Hijazi O

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2736: Analytical Characterization of Soil Resources

Version of module description: Gültig ab summerterm 2021

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:

The students hand in a research paper (10-15 pages), in which they present and discuss the analytical data obtained by own laboratory characterization of soil samples that were collected by the students themselves during a guided exercise in the field. The research paper is accompanied by an oral presentation (15-20 min) to assess the scientific communication skills of the students. For the final mark, the research paper accounts for 75% and the oral presentation for 25%.

Repeat Examination:

Next semester

(Recommended) Prerequisites:

The successful completion of the module "Introduction to Soil Science" (WZ2733) or equivalent skills are required.

Content:

- Sampling and sample preparation
- Lab analyses: texture, density, water conductivity, organic and inorganic carbon, nitrogen, soil organic matter decomposition, pH, cation exchange capacity, Fe oxides, phosphate retention;
- Data interpretation

Intended Learning Outcomes:

The students are able to apply their knowledge of soils, as achieved in the module “Introduction to Soil Science”, to the most important physical, chemical and biological processes in soils. They are able to choose the adequate
laboratory method to answer a certain question on soil management. They know how to do sampling, sample preparation and laboratory work. They can interpret laboratory data and know, which conclusions can be made and which conclusions cannot be made. The students are able to communicate their results in a written and an oral manner.

Teaching and Learning Methods:
For every step, the lecturers give the theoretical background. Afterwards, every step is done by the students themselves, guided by the lecturers and the laboratory staff: sampling, analyses, data interpretation.

Media:
Lecture: presentation notes; sampling: field equipment; laboratory course: laboratory instruments

Reading List:
will be given in the course

Responsible for Module:
Schweizer, Steffen; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Analytical characterization of soil resources: Laboratory course (Übung, 3 SWS)

Analytical characterization of soil resources: Lecture (Vorlesung, 1 SWS)
Schweizer S

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2757: Advanced Environmental and Natural Resource Economics | Advanced Environmental and Natural Resource Economics

Version of module description: Gültig ab summerterm 2017

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a written exam (90 min), a presentation (20 min) and a term paper (around 10 pages). The written exam shall give proof that the lecture content was understood and that it can be applied in exemplary exercises. Both the presentation and the term paper shall analyse a lecture topic in detail and place it in the economic environment. Weighting is as follows: 50 % written exam, 40 % term paper, 10 % presentation.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Environmental and Natural Resource Economics (recommended)

Content:
Dynamic optimization; Theory of optimal extraction of renewable and non-renewable resources; Theory of joint production; Application of game theory to resource management; Optimal growth and green accounting

Intended Learning Outcomes:
At the end of the module students have a profound knowledge of the economics of resource problems. They can derive the optimal time path to use renewable and non-renewable resources. They can explain how resources can be incorporated in the theory of optimal growth and how they can be accounted for in welfare and sustainability measurement. They can explain how some welfare enhancing effects are produced as a side effect of production systems. They are able to apply resource economic theory to real life resource problems. They know how to apply the basic concepts of game theory and how these can be used to explain the (im)possibilities of reaching international environmental agreements.
Teaching and Learning Methods:
Lectures will be used to teach the theoretical material. Exercises will be used to apply the theory taught in the lectures to solve problems and to facilitate a better understanding of the subject matter. In order to enable students to critically reflect on lecture topics, interactive elements are integrated (e.g. group work, case study).

Media:
Lecture notes, Excel

Reading List:
will be told in the lecture

Responsible for Module:
Sauer, Johannes; Prof. Dr. agr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Environmental and Natural Resource Economics (Vorlesung, 4 SWS)
Sauer J [L], Canessa C, Mennig P, Villalba Camacho R
For further information in this module, please click campus.tum.de or here.
Module Description

WI001190: Cooperation and Integration in Agribusiness | Cooperation and Integration in Agribusiness

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module assessment will be in the form of 120-minuten written exam. In the exam, students should demonstrate that they understand the theoretical concepts and apply relevant analytical methods to solve problems. In addition, the students should prove that they can analyze practical problems, assess the various forms of cooperation and networks in agribusiness, and develop appropriate solutions for strategic cooperation and integration.

Repeat Examination:

(Recommended) Prerequisites:
Basics of sustainability and organizational collaboration

Content:
The module deals with the complex forms and approaches of cooperation and integration in agribusiness in order to improve the performances of agricultural enterprises. Specific topics of the module are:

• Theoretical approaches and basics of cooperation and integration with a focus on the concept of institutional economics (resource-based theory, transaction cost economics, contract theory, principal-agent approach, value chain governance and interventions including certification programs)
• Strategic options of horizontal and vertical integrations
• Forms of customer, business relationship and stakeholder management
• "Lean Management" and corporate collaborations
• Sustainability in the agri-food value chain and entrepreneurial activities
Intended Learning Outcomes:
Upon completion of the module, students will be able to:
• understand collaboration dynamics, challenges and problems as well as related solutions,
• use relevant qualitative and quantitative methods to analyze and improve business collaborations within the value chain,
• analyze and evaluate agribusiness related horizontal and vertical integrations,
• develop and design strategies for effective agri-food entrepreneurial collaborations and integrations.

Teaching and Learning Methods:
Lecture with integrated individual exercises, group work and case study analysis. The lecture is used to teach the theoretical concepts and approaches. Individual assignments, group work and case studies are used to work on specific empirical problems and to find solutions. This also includes learning through literature analysis.

Media:
Presentations (power points), case analysis formats and scripts

Reading List:
Fischer, F., et al. (2010), Factors influencing contractual choice and sustainable relationships in European agri-food supply chains. European Review of Agricultural Economics, 36(4): 541-569
The list will be expanded and updated using other thematically relevant books, journal articles and periodical newsletters and others.

**Responsible for Module:**
Sauer, Johannes; Prof. Dr. agr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Cooperation and Integration in Agribusiness (WI001190) (Vorlesung, 4 SWS)
Abate Kassa G [L], Abate Kassa G
For further information in this module, please click campus.tum.de or here.
Module Description

WZ1590: Climate Change Economics | Climate Change Economics

Version of module description: Gültig ab winterterm 2014/15

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter/summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>60</td>
<td>90</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
There will be a written exam (Klausur) of 90 minutes at the end of the semester. The students will be asked to demonstrate, within the stipulated amount of time using predefined methods and resources, their ability to outline the challenges climate change poses to regulators, propose pragmatic solutions and strategies as well as ways of implementing them. This would be based on the competences acquired from the relevant literature of economic modeling, theories of climate change and their understanding from the course content. The written exam is an appropriate assessment method to evaluate the degree to which the students understand the theoretical framework of climate change implications as well as provides an opportunity for them to put forward arguments based on existing theory.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge:
• Micro Economics (Welfare Economics)
• Environmental Economics
• Resource Economics

Content:
This course covers the trends in current and future climate change and their effects on economic and social outcomes.

The lectures are divided into ten sessions:
1. Introduction to the Basic Science of Climate Change
- The students will learn about the scientific themes of global climate change and the economic dimension of the phenomenon.
2. Basic Economics
- The students will learn how a market economy can be efficient and socially optimal as well as about the prospects of externality.

3. Optimal Emission Levels
- The students will learn of the optimal abatement path and its uncertainty with respect to damages as well as Integrated Assessment Models (IAMs).

4. Intra-generational equity in climate policy
- The students will learn about how to account for equity across space (intergenerational equity) when deriving optimal emission levels.

5. International Environmental Agreements
- The students will learn about the dynamics behind common strategies towards achieving some form of optimal emission level.

6. Policy Instruments
- The students will learn about diverse instruments such as quality-based approach and Pigouvian Tax.

7. Regulation via Prices vs. Quantities
- The students will learn what circumstances will a regulator prefer prices over quantities and vice versa.

8. Credit-based Mechanisms
- The students will learn about how to deal with countries that do not want to commit, but have a high potential for low-cost reductions.

9. German Climate Policy
- The students will learn about German Climate Action - strategies and policies

10. European Union Emission Trading Scheme - EU ETS

**Intended Learning Outcomes:**
After successfully completing the module, students are able to:
- Evaluate and formulate economic models related to climate change.
- Apply theoretical model to climate change regulations as well as policies that affect emission levels.
- Analyze the complexity, uncertainty and possibilities associated with optimal emission level.
- Apply appropriate instruments for optimal emission level that are efficient and cost-effective.
- Understand climate negotiations (club) and climate action strategies are currently being implemented.

**Teaching and Learning Methods:**
The course mainly consists of lectures (4 SWS). The lecture will provide a foundation upon which to build the ensuing discussions on climate change issues from an economic perspective. The content of the module is expected to be transferred to the students in an interactive learning manner were, among others, emission reduction instruments are scrutinized. This encourages the students to independently and self-reliantly study the literature guided by a structured framework.

**Media:**
PowerPoint, flipchart, internet portals, online reports etc.
Reading List:

Responsible for Module:
Sauer, Johannes; Prof. Dr. agr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2730: Climate Change - Science, Impacts and Adaptation, Mitigation | Climate Change - Science, Impacts and Adaptation, Mitigation

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Assessment consisting of oral examination (30 min) on the lecture and the seminar. In this oral examination the student is expected to demonstrate that he/she has understood the physical basis of the climate system and that they can identify the drivers of climate change. The student shows that he/she is able to apply his/her knowledge to develop adaptation and mitigation measures and to argue in discussions on climate change issues. A voluntary mid-term assignment (presentation) in the seminar assesses the students’ ability to summarize findings from scientific publications / case studies and to present them to an audience. The presentation is complemented by the preparation of a "PICO" that is presented on an interactive screen. The presentation will serve for grade improvement by 0.3 according to §6(5) APSO.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in meteorology, physics, biology.

Content:
Based on the newest IPCC report (AR 5) the theoretical background on the physical science basis of climate change, theory and practical application of adaptation and mitigation measures in biological, physical and chemical systems will be presented. In a related seminar, selected topics will be intensified in case studies. TUM as a NGO in the UNFCCC process offers an optional possibility also for students to take part in COP and related negotiations.

Intended Learning Outcomes:
After this module, the students can understand the physical basis of the climate system, identify all drivers of climate change and falsify common arguing of "climate sceptics". They can summarize
observed changes in the climate system as well as impacts in diverse systems and regions. They are able to assess cross-sectorial impacts of climate change in selected areas, to evaluate and develop adaptation and mitigation measures and strategies in biological, physical and chemical systems including an analysis of their effectiveness and cost-effectiveness.

**Teaching and Learning Methods:**
Lecture on physical basis of the climate system, impacts of climate change and important mitigation strategies. In the seminar group presentations of various topics regarding adaptation and mitigation of climate change will be presented as case studies. Optional excursion to UNFCCC meeting if applicable.

**Media:**
Lecture with PowerPoint Presentation, reader and exercises. Group work in seminar including problem driven case studies and student presentations, excursion.

**Reading List:**

**Responsible for Module:**
Rammig, Anja; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Ecological, social and economic aspects of CC impacts, adaptation and mitigation on different scales (Seminar, 2 SWS)
Estrella N [L], Menzel A, Estrella N

Climate Change - The complete briefing (Vorlesung, 2 SWS)
Rammig A [L], Buras A, Krause A

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://campus.tum.de).
Module Description

**POL62200: Energy Transformation | Energy Transformation**

Version of module description: Gültig ab winterterm 2017/18

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter/summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

**Description of Examination Method:**
For this module, evaluations will be based on written work and a presentation. The written assignment for the module will be of a length of approximately 20-25 pages. The topic of the module paper is to be developed in consultation with the seminar leaders and will deal with a specific topic of the seminar (energy transformation) and its technological, political, and social dimensions. The paper will be introduced with a precise question and then analyzed in depth. The methodology of research needs to be indicated and a comprehensive bibliography included. Students will be expected to prepare and give a presentation of at least 20 minutes tied to a session topic. Group presentations of up to three students are possible as long as individual contributions are discernible.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Ring lecture „Politics & Technology“

**Content:**
For a variety of reasons, including energy security, environment and climate concerns, and the potential to develop new technologies and processes, cities, countries and entire regions are pursuing low-carbon energy transitions. Understandings of what the best approach to a low carbon energy transition is, however, vary widely. The extent to which energy transitions are occurring in various sectors (power, heating/cooling, transportation) differs significantly. Why is this the case? What factors support or inhibit the scaling-up of policy solutions? What are the challenges associated with large scale energy system transformations? How similar or different are energy system transformations to other major transformations which have occurred in the past or which may need to occur in the future? This module will consider these and other questions in the context of Germany, at the European level and internationally.
**Intended Learning Outcomes:**
After participating in this module, students will understand the arguments underpinning decisions to pursue low carbon energy transitions, how low carbon energy transitions are affected by broader economic, technological, and political factors, and the ways in which actors at the local, national, or international level may act to promote or inhibit change. They will have gained insights into system transformation thinking, understand aspects of the production, distribution and utilization of energy and their interplay; apply methods of comparative policy analysis to energy policy in different political systems; be able to identify challenges of policy-making in national politics and the European multi-level system; to critically analyze energy policy in Germany, Europe, and internationally (for example in China, Japan, India, the United States as well as at the global level); to analyze the factors determining German, European, and international energy politics, and to evaluate the effects of different energy policy governance instruments (like legal regulation, planning, incentive design, taxes, subsidies, etc.).

**Teaching and Learning Methods:**
The module is offered in the form of two seminars, each dealing with different, but complementary thematic areas. One will be focused more on the transition of the energy systems in Germany and Europe while the other will concentrate more on the international and global level. To obtain a deeper understanding of the module’s topics a combination of independent work and general discussion will be used in the seminar. Seminars will include both direct input from the instructor and a wide variety of active learning methods. During the seminars, there will be in-depth discussions and inputs by students. Concrete examples will be used to practice, analyze, and evaluate the material which has been presented. Both the technical and scientific aspects of issues as well as their political and social implications will be discussed. The presentations developed and given by the students and ensuing discussions will contribute to the students' understanding of the seminar materials and instructor's inputs.

**Media:**
Online-Reader, PowerPoint

**Reading List:**


A reader of seminar texts with up-to-date and cutting edge scientific literature will be made available at the start of the semester.

**Responsible for Module:**
Schreurs, Miranda; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
(POL62200) Energy Transformation (Seminar 1 + 2) (Seminar, 4 SWS)
Cetkovic S (Mohammed N)
For further information in this module, please click campus.tum.de or here.
**Module Description**

SOT86700: EuroTeQ Collider - Leave no Waste Behind (Master) | EuroTeQ Collider - Leave no Waste Behind (Master)

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

**Description of Examination Method:**

During this module, students must complete following tasks: producing a presentation that provides information on the project concept development and implementation, as well as a final report, charting the progress of their work/research over time. These assessments will evaluate a) the success of the project and b) the learning success of the students in oral and written form.

Students will be graded based on the active participation in a group project (20%), a final presentation of project results (60%) and a final project report (20%). These examination requirements will assess the success of the project, but also examine the learning success of the students in oral and written form.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

This module is aimed at all students enrolled in a Bachelor or Master program at the TUM; it is thus designed as an interdisciplinary venue which brings together a range of scientific perspectives. No specific prior knowledge is required; however, its project-based character requires high levels of intrinsic motivation and the willingness to actively participate in a project.

**Content:**

The way we live today produces a lot of waste. Aware of this fact, many initiatives try to stop this trend and reduce the amount of waste left by mankind. But there is still a lot to do! Waste is everywhere, not only in the use of packaging, in the over-use of natural resources, in the unuse of surplus or in the non-management of certain types of waste (chemical, nuclear). It also results from non-optimization of certain processes (energy loss during electricity production, extraction efficiency of certain materials), in our inability to find sustainable alternatives (fossil fuels) or to
consume differently (buy rather than repair). The process of waste reduction just began, and in order to succeed in leaving no waste behind, what will your contribution be? The Technical University of Munich (TUM) joint forces with six leading universities of science and technology to foster the European spirit in a EuroTeQ format to promote innovative engineering education across Europe. Together we are creating the first EuroTeQ Collider in 2022. The Collider is an innovative learning format with the aim of bringing students together with vocational trainees and professionals to tackle challenges around the theme “Leave no waste behind”. The goal is to connect participants with different profiles and personalities to boost creativity, innovation, shared understanding, enabling participants to imagine new approaches and design disruptive solutions. The module is a seminar which gives students the opportunity to apply their knowledge on topics related to the theme “Leave no waste behind”. Within this overarching theme, we are offering challenges on three different topic-domains, namely:

- Cities (eg. construction/building, public lighting, streets (trash bins))
- Energy (eg. renewable resources, transport, data (storing))
- Consumption (eg. food, plastics, fashion).

Within every topic domain, interdisciplinary (and international) teams of students, vocational trainees and professional learners are formed to develop solutions towards a desirable future, test and validate tools and create prototypes of their solutions. A selection of the best projects will be presented in a major high-level event, the EuroTeQaThon. The winner teams of the EuroTeQaThon will be invited to present their projects at the European Commission.

**Intended Learning Outcomes:**
After completion, all EuroTeQ Collider participants will be able to:
- Select and apply appropriate design, engineering and business approaches and tools to create an innovative and science-based solution to a real-life challenge.
- Develop a profound interpretation of a complex, real-life problem and its context using a system-thinking approach, considering multiple perspectives.
- Develop a problem-driven, creative, and integrative design, demonstrated by a concrete prototype that balances desirability, feasibility, and viability.
- Use disciplinary knowledge and expertise in an inter-disciplinary team to develop an innovative and scientifically sound solution in a European context.
- Communicate your ideas, at different levels of elaboration, via several mediums in an international context to a diverse set of stakeholders.
- Define and regularly reflect on personal and team development

**Teaching and Learning Methods:**
A range of teaching & learning techniques will be applied:
- (pre-recorded) videos and online presentations, with podcasts and interviews, Q&A Sessions with experts
- This module is focusing on service-learning and project-based learning
- After a set of introductory sessions which provide input on the core topics but also project management, students will work on their projects in groups. Progress will be determined through
project presentations during the semester, continuous feedback from the instructors, as well as peer-to-peer feedback. –
- Presentational skills will be further facilitated through the requirement to present the final results
- As students and professionals will work together in a joint effort, all participants will not only improve their technical skills but also enhance their soft skills such as team spirit, flexibility to work in multicultural environments, and design thinking, which are also very important in professional life.

Media:

Reading List:

Responsible for Module:
Wurster, Stefan; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
(SOT82700, SOT86700) EuroTeQ Collider - Leave no Waste Behind (Seminar, 4 SWS)
Becker V, Wurster S (Schmid H)
For further information in this module, please click campus.tum.de or here.
Module Description

WI000286: Environmental and Natural Resource Economics | Environmental and Natural Resource Economics

Version of module description: Gültig ab summerterm 2017

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning success will be assessed by a written exam (120 minutes).
By answering the questions students show that they are able to understand the economic view of environmental and resource problems. Furthermore students show that they are able to compare and evaluate alternative economic instruments (e.g. taxes, emission permits, payments for environmental services). They show their ability to apply environmental policy instruments and valuation methods to specific problems. Finally students demonstrate that they are able to conduct and interpret economic cost-benefit analyses.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
A basic knowledge in Microeconomic theory is recommended

Content:
a) Economic growth and the environment
b) Economic analysis of environmental problems
c) Role of institutions and liability rules
d) Analysis of environmental economic instruments
   - Command and control measures
   - Pollution taxes
   - Emission trading
   - Payments for environmental services
e) Valuation methods for environmental goods
f) Cost-benefit analysis.
Intended Learning Outcomes:
At the end of the module the students are able to understand the economic view of environmental and resource problems. They know alternative economic instruments, e.g. taxes, emission permits, payments for environmental services and how they work and are able to compare them regarding their economic efficiency. They know and can apply specific valuation methods to attach a monetary value to environmental effects and conduct and interpret economic cost-benefit analyses.

Teaching and Learning Methods:
The module will be held in the form of lectures which are partially combined with group discussions and exercises. The main learning objective is here to understand the economics of environmental policy. Lectures are a format suitable to convey theoretical knowledge about the welfare implications of policy interventions. Integrated exercises will help students to apply acquired knowledge to concrete problems and derive economically sound answers.

Media:
PowerPoint

Reading List:
A digital reader consisting of various textbook chapters and journal articles will be put on Moodle for each chapter of the course.


Responsible for Module:
Glebe, Thilo; PD Dr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Module Description

WI001204: Economics of Water Use, Regulation and Markets

Version of module description: Gültig ab winterterm 2018/19

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a written examination at the end of the semester of 120 mins (in class), students will demonstrate the ability to understand and analyze concepts and methodological approaches related to water resource management using economic terminology, and the ability to apply mathematical tools to solve specific calculus problems. A written exam is necessary in order to assess the holistic understanding and analytical competencies of the students. Students will have to option to give an in-class presentation (~15 min) of a paper related to water resource economics that they will choose from a list of references provided by the instructor. The in-class presentation (mid-term assignment) is optional and improves the final grade by 0,3. The extra credit from the in-class presentation cannot be transferred in the case of re-examination.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Students taking this course should be familiar with the basics of microeconomics as well as mathematical economics (derivatives, basic function integrals and graphs). However, all necessary concepts will be introduced before application.

Content:
The course will examine the incentives that lead to overexploitation of water recourses and how altering these incentives can promote socially optimal use patterns. The course will also provide the students with a set of analytical tools that can be used to work on water issues or natural resource issues more broadly.
Those topics are:
1. Introduction and Economics Basics
2. Agricultural Water Use
(water rights, agricultural water use efficiency and productivity, land allocation, technology choice, environmental quality)
3. Residential Water Use
4. Water, Land Use and Environmental Aspects of Biofuel Production
5. Other Approaches to Value Water
(hedonic modelling, experimental economics, nonmarket valuation approach)
6. Intertemporal and Interregional Aspects of Water
7. Water Markets Around the World
(Europe, China, USA)

Intended Learning Outcomes:
This course is designed to introduce students to the subject of water economics. Upon successful completion of the module, students will be able to:
• understand the basic concepts and economic models used to study the economics of water resources issues.
• select and apply the appropriate economic model to solve water policy problems as for example producer’s profit or consumer’s utility maximization.
• provide economic intuition for mathematical answers to water management problems.
• apply models to address a wide range of water resource problems and assess the economic effects of decision making process at different levels based either on the water demand or the water supply side of the economy.
• critique journal articles pertaining to economics of water resources.

Teaching and Learning Methods:
Theoretical concepts and example exercises will be given by the lecturer on the blackboard and by PowerPoint presentations to build the required knowledge base in water resource economics. Q&A sessions at the beginning of each lecture will be provided to recapitulate the previous lecture. In addition, under the supervision and help of the lecturer, in-class application exercises will be used to create real-world water management problems for which students in randomly assigned groups will create and solve problems. Discussion of relevant scholarly articles and literature will be used to aid understanding of the topic covered.

Media:
Presentation slides, Blackboard, hand-outs, Moodle course to provide materials (pdf of papers to read)

Reading List:

The list will be expanded and updated using material from a variety of textbooks and journal papers corresponding to each of the topics.

**Responsible for Module:**
Prof. Dr. Johannes Sauer Jo.sauer@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://example.com).
Module Description

WZ0228: Exercises in Precision Agriculture and Plant Phenotyping | Exercises in Precision Agriculture and Plant Phenotyping

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination uses the format of Report (project report + presentation), in which students should demonstrate that they are able to apply the gained skills to address certain questions in research or applications, in the context of (but not limited to) precision agriculture and plant phenotyping. The final grades are calculated from the following elements:
- On the topic of choice, each group of students (e.g., 3-4 persons but can also be solo) writes a project report (8-10 pages of A4 single line format, excluding references) (75% of the total grade), and
- Each group presents project results in 15 min following 5 min discussion (25% of the total grade).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
- Knowing the basics of scientific programming (e.g., R, Matlab) is recommended.
- Knowledge gained in the course module "Precision Agriculture" is recommended, but not mandatory.

Content:
The module aims to transfer the practical methods and skills of using novel technologies for precision agriculture and plant phenotyping. Main topics include:

1. cameras, sensors, and integrated systems used in precision agriculture and plant phenotyping;
2. basics of using Matlab, R, and other related software packages;
3. drone (UAV) operation, image data acquisition and analysis pipeline;
4. spectrometer operation, plant and soil spectral measurements, and spectral data analysis;
5. digital image analysis methods and software packages;
6. GIS tools for spatial data analysis and visualization;
7. satellite imagery data acquisition, processing, and analysis;
8. detection of plant biotic and abiotic stresses using different sensors;
9. measuring field spatiotemporal variability and crop yield;
10. data science methods in precision agriculture and plant phenotyping;

**Intended Learning Outcomes:**

Upon completion of the module, students will be able to:
- understand the basics of characterizing plant traits and crop field variability using non-destructive methods;
- apply basic sensors and software packages (e.g. R, Matlab) in practices;
- evaluate the potentials and limitations of different sensors and data science methods (e.g. for image segmentation and classification);
- design sensing and data analysis pipelines for solving practical problems;
- develop critical and systematical thinking skills;
- to present their results in a clear and comprehensible manner to an audience

**Teaching and Learning Methods:**

- The module delivers the practical skills of precision agriculture and plant phenotyping through demonstrations of operational and analytic methods, hands-on practices, and computer exercises.
- Students actively participate in the exercises and discussion, and write learning journals to reflect the critical aspects in the exercises, e.g., application potentials and limitations of methods.
- Students conduct exercises through teamwork, write reports on topics of choice, and present the results and discuss with classmates.

**Media:**

Zoom, Scripts, PowerPoint

**Reading List:**

- Current literature related to the topics

**Responsible for Module:**

Yu, Kang; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description

WZ1876: Entrepreneurship in the Agricultural and Horticultural Industry
| Entrepreneurship in der Agrar- und Gartenbauwirtschaft

Version of module description: Gültig ab winterterm 2018/19

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination consists of a 120-minute written exam. This will focus on testing the holistic understanding and competence with regard to the conceptual and methodological approaches in agri-food entrepreneurship.
In addition, students will analyze business start-up processes and risks in the innovation and product development process, assess entrepreneurial cooperations in the agricultural and horticultural sector, and design associated management and organizational structures.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamentals of Microeconomics, Market analysis

Content:
The module covers and discusses the principles, theoretical approaches and significance of entrepreneurship orientations to support the application of innovations and start-up related economic activities in the agricultural and horticultural value chains and industries. The course specifically includes the following topics:
- Principles of entrepreneurship and entrepreneurship orientations in the agricultural and horticultural industries.
- Innovation and product development processes and related entrepreneurial opportunities and risks
- Entrepreneurial strategies and collaborations in the venture creation process
- Methodological approaches (e.g. attribute mapping, strategy canvas and various business model and quantitative approaches) to explain and evaluate entrepreneurship-related activities and venture creation processes
- Sustainable entrepreneurship

**Intended Learning Outcomes:**
After successful completion of the module, students will be able to:
- understand the principles of entrepreneurship and business creation in the agricultural and horticultural sector,
- use qualitative and quantitative methods to explain and evaluate entrepreneurship related activities,
- analyze the risks and opportunities in innovation and product development,
- assess collaborations and strategies in entrepreneurship and business creation, and
- develop venture creation processes, associated management, and organizational structures.

**Teaching and Learning Methods:**
With the help of lectures, the theoretical approaches and concepts of entrepreneurship and the business start-up process are taught. Group work and presentations are used to describe and work on practical problems and proposed solutions.

**Media:**
Presentations, case descriptions, scripts

**Reading List:**

Die Liste wird anhand von weiteren thematisch relevanten Büchern, Zeitschriftenartikeln und aktuellen Themen aktualisiert

 Responsible for Module:
Getachew Abate Kassa getachew.abate@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2724: Emission Control in Land-Use and Animal Husbandry | Emission Control in Land-Use and Animal Husbandry

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level: Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
<th>Frequency: winter semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits:* 5</td>
<td>Total Hours: 150</td>
<td>Self-study Hours: 105</td>
<td>Contact Hours: 45</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The oral examination will be held either as an individual or a group examination. If more than 40 students sign in for the examination the oral examination can be done in a written form (Klausur, 90 min). The duration of the oral examination is 20 min per person. The Students are able to describe typical agricultural production, the environmental impact and the measurement procedures to quantify and to qualify these impacts. On that basis they are able to weigh the advantages and disadvantages of possible measures of air pollution in agriculture.

Repeat Examination: Next semester

(Recommended) Prerequisites:
Interest in the field of agriculture; willingness to learn about the causal relation between agriculture and emission control.

Content:
Upon completion of the module, students are able to understand and analyze:
- the principle of agriculture in plant and livestock production on a basic level
- the main emissions caused by agricultural processes on a deeper level
- interactions of agricultural processes with the emission
- the environmental effects of these emission
- the measurement procedures to qualify and quantify agricultural emissions
- possibilities of emission abatement in land-use and animal husbandry.

Intended Learning Outcomes:
At the end of the module students are able to:
- understand the interrelation between local causes and global impacts,
- apply the comprehension of basic physical, chemical, and biological principles to phenomena in practice,
- evaluate measurement techniques in a qualitative manner,
- evaluate measures and techniques of environment protection;
- understand the interrelation between animal husbandry and air pollution control,
- derive adequate measures of environmental protection.

**Teaching and Learning Methods:**
Lecture, practice course.

**Media:**
PowerPoint-slides, short clips.

**Reading List:**
Tba

**Responsible for Module:**
Dr. Stefan Neser – Bavarian State Research Center for Agriculture; Institute for Agricultural Engineering and Animal Husbandry; Voettinger Strasse 36, 85354 Freising, 0049 8161 713566; stefan.neser@lfl.bayern.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Emission control in Land-Use and Animal Husbandry (Vorlesung, 3 SWS)
Neser S
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2732: Environmental Monitoring and Data Analysis | Environmental Monitoring and Data Analysis

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Upon completion of the module, the students have a profound understanding of key aspects of environmental monitoring and are able to choose appropriate as well as to efficiently run environmental measurements, to reproducibly analyze acquired data and to clearly communicate results of environmental measurements.
This ability should be demonstrated by writing a research paper following standards of reproducible research based on different aspects of environmental monitoring and data analysis with R. For the research paper, either available data or data measured during the module should be used and be analyzed in respect to defined hypotheses; developed R code has to be provided too.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in R is recommended.

Content:
1 Environmental monitoring including principles, techniques and management issues used in environmental monitoring and assessment; Observing, recording, communicating and archiving collected data and providing it to project stakeholders in order to identify sustainable and responsible environmental practices.
Optional: short course Aerobiology, GAW program, visit of companies

2 Environmental data analysis
Introduction to data analysis with R; Principles of reproducible research and implementation with R; Pipelines for environmental data analysis from obtaining data via cleaning and transforming to modelling and visualization with modern R; Coverage of data retrieval from different storage
types for climate, proxy, phenology, and other data (text-based, netCDF, data bases); Modeling and visualization as complementary strategies for hypothesis-driven data analysis, based on published research from different fields of environmental sciences.

**Intended Learning Outcomes:**
After this module, the students can plan, implement and run environmental measurements. They are able to efficiently analyze environmental data sets, including download and import of data sets and visualization and modelling with R.

**Teaching and Learning Methods:**
Course 1 consists of a practical course in the laboratory and in the field where students will work in small teams on applied case studies and exercises related to environmental / meteorological monitoring. Course 2 then offers combined lecture and exercise sessions at the PC lab on how to efficiently analyze those environmental data sets of course 1.

**Media:**
PowerPoint Presentation, Field work, Interactive documents for data analysis

**Reading List:**
Beginner level tutorials for Swirl (http://swirldocs.com/)

**Responsible for Module:**
Responsible for Module: Prof. Dr. Annette Menzel - Professur für Ökoklimatologie Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, 08161/ 71-4740, menzel@wzw.tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Environmental monitoring and data analysis; ecological data analysis (Vorlesung mit integrierten Übungen, 3 SWS)
Menzel A [L], Buras A, Lüpke M

Environmental monitoring and data analysis; ecological monitoring (Vorlesung mit integrierten Übungen, 2 SWS)
Menzel A [L], Lüpke M

For further information in this module, please click campus.tum.de or here.
Module Description

BGU62039: Case Studies of Sustainable Urban Developments and Infrastructure | Fallstudien nachhaltiger Quartiers-, Stadt- und Infrastrukturerentwicklungen [FNQSI]

Version of module description: Gültig ab summerterm 2021

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination performance is achieved by writing a scientific paper in the form of an essay (about 5-7 pages). This is worked on in groups of 2-3 students. At the end of the semester, the results are presented in a graded short lecture and finally discussed.
The aim is to demonstrate that the students have understood and can critically reflect on the essential aspects of how sustainable neighborhood, urban and infrastructure development was implemented in the case study and that they can present their findings in an appropriate form.

The overall grade of the module is composed of the essay (70%) and the short presentation (30%).
The examination is done online: the essay is uploaded on Moodle and the presentations take place via ZOOM.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
The contents of the modules

BV620007 Fundamentals of sustainable construction
BV000029 Traffic engineering and traffic planning basic module
BV000031 Urban water and waste management basic module

should be familiar to the students
Content:
In this module, the connections between urban planning and engineering as well as architectural concepts and the energy, material and traffic flows associated with them are shown and, above all, their implementation is dealt with in more detail.

Individual projects in the field of building construction and civil engineering as well as infrastructure systems and settlement quarters are examined and analyzed in more detail. The implementation of these projects, taking into account the location, social and societal aspects, as well as the integration of energy and political issues, are examined in a practical manner using case studies. The new building as well as projects of the reorganization, projects in the range plus energy house, zero-emission quarters are consulted.

Here, the criteria of sustainability are exemplarily dealt with in the phases of planning, construction, operation and deconstruction, in order to be able to evaluate buildings, structures, systems and developments in an active discussion in the future.

Intended Learning Outcomes:
After attending the module, students will be able to:

- apply the criteria for sustainability on the basis of exemplary projects and understand their influence on and interactions with the parameters involved.
- understand sustainable developments in cities and neighborhoods as well as civil engineering and building construction from spatial, structural, material, cultural and social aspects.
- evaluate the different subsystems such as infrastructure, building stock, new construction, urban planning framework, energy supply, traffic, mobility, water, waste, food, education, social structure, resources/cycles at neighborhood level, microclimate, quality of life, social structures, use structures, economic structures.
- Understand concepts of active and passive building technology as well as intelligent building envelopes and building control systems.
- to understand factors such as comfort, climate, energy consumption, finiteness of resources and CO2 emissions and their mutual influence.
- understand scenic analyses and examples and apply them to other properties with their own proposed solutions.

Teaching and Learning Methods:
The module consists of a lecture series and a seminar.

In addition to the lecturers, external experts from science and practice are involved in the lecture series. The various actors in urban development provide the students with practical insights into the different subsystems of the city and are available for discussions.
In the seminar, the content taught in the lecture is further deepened through interactive formats such as workshops, discussions, student presentations and group mentoring, as well as a multi-day field trip to the current case study.

Participants* in the module each choose a topic/object from the course content at the beginning of the semester. The possible focal points are related to the case study of the current semester. These are assigned to one of the overarching themes of the city, such as material flows, mobility, neighborhoods, or buildings.

During the semester, the chosen topic/object is intensively studied by the students, visited on site if necessary, and presented. The development takes place in small groups of 2-3 students each. In addition, individual contents and methods are further deepened in accompanying workshops. The intermediate presentations, in the course of the development of the essay, serve as practice.

The students actively participate in the excursion components and develop their own concepts and strategies.

Towards the end of the semester, the result is submitted as a written paper (essay of 5-7 pages plus graphics, images, appendices, etc.). It is then presented in the form of a short lecture and discussed together. As a rule, the students present the work of another group.

Media:
Slides, lecture notes (to be developed from each semester's lecture focus), posters, presentations. Field trips and site visits to the properties discussed in the case studies with supporting guest lectures and on-site tours.

Reading List:

Responsible for Module:
Prof. Dr.-Ing. Werner Lang sekretariat.enpb.bgu@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2716: Forest Growth and Forest Operations | Forest Growth and Forest Operations

Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning success of the module Forest Growth and Forest Operations will be assessed by a written examination of 90 minutes. This is due to the fact that biometric topics, growth processes and analyses as well as the forest growth modelling part of the lecture can be presented best in a written form by drawings, figures, calculation schemes, etc. For example the description of biological processes and growth cycles in forest growth simulators can best be explained and depicted by graphical representations.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in biology and forest science.

Content:
The part Forest Growth deals with objectives and methods of forest growth and yield science. First, as fundamental topic, principal factors of the organic production of forest stands based on the driving forces (climate, water, nutrients) are shown and explained. In a next step growth and yield is analyzed more closely as part of the total production of plant communities. This leads to principles of tree shape development, tree growth and carbon dynamics in general. From individual tree growth the course proceeds to structure and development of whole forest stands. Both previous subjects provide the basic knowledge for understanding the effect of silvicultural treatment on quantitatively measured growth and yield characteristics. Growth trends, productivity and carbon dynamics of the main tree species in Central Europe are presented. Analyses of stand structure, growth and yield in the view of climate change are discussed. Different types of forest growth models on tree, stand and forest enterprise levels are introduced. The part Forest Operations can be divided in 5 topics: (1) Overview of mechanized harvesting (methods and
most common systems), (2) Environmentally sound resource road planning and construction, (3) Assessing the environmental impacts of forest operations on forest stands and soils, (4) Means of eco-efficient wood transportation from the forest to the mill and (5) Current developments in small-scale forest operations.

**Intended Learning Outcomes:**
On successful completion of the module, students are able to
- Understand the environmental factors influencing the forest stand production
- Describe the effects of silvicultural treatment on quantitatively measured growth and yield characteristics
- Understand the principles of growth models
- Analyze and evaluate the impact of environmental changes on tree and stand growth
- Create possible silvicultural measures to mitigate negative effects of environmental changes on forest stand growth
- Understand and evaluate the impact of biotic and abiotic factors on growth, vitality and stability of individual trees and forest stands
- Understand the fundamentals of sound resource road planning and construction
- Describe the links between mechanized harvesting and potential stand and soil damages
- Evaluate the productivity and carbon footprint of different harvesting systems.

**Teaching and Learning Methods:**
Lectures and presentations, field trip (optional).

**Media:**
Lectures and presentations (pdfs).

**Reading List:**

**Responsible for Module:**
Rötzer, Thomas; Apl. Prof. Dr. agr. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**
For further information in this module, please click campus.tum.de or here.
Module Description

WZ4098: Forestry Raw Materials and their Utilization | Forestry Raw Materials and their Utilization

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning success will be assessed by a written examination (duration 60 min) where students are expected to demonstrate the level of knowledge and their ability to use and apply it in solution finding strategies. Additionally a midterm Assignment (voluntarily), the students have to prepare and give a structured oral presentation in a seminar organized at the end of the summer term. The topic of the presentation is defined in agreement with the lecturer. The presentation may be prepared either individually or in groups of two. The midterm presentation Assignment allows to improve the examination mark by 0.3.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basics of biology, chemistry, physics and sciences to deal with the biological production, and the processing and conversion processes of wood to final products, and the environmental assessment.

Content:
1. Overview and global potential of forest resources;
2. Availability, characteristics and properties of forest based products (wood and non-timber forest products);
3. Technologies and processes from raw materials to final products: sawn timber, wood-based products, pulp and paper;
4. Criteria and rules of a resource efficient application;
5. Environmental assessment of forestry raw materials and products.
Intended Learning Outcomes:
Upon successful completion of the module students are able to:
- illustrate the multidisciplinary of forests and their products;
- propose options to maximize the value chains of forest based products;
- exemplify production and process technologies and typical sector industries;
- demonstrate the role, potential and limitations of forestry raw materials in the framework of sustainable development;
- outline economical, environmental and social aspects of typical products and applications;
- develop strategies to strengthen the value and impact of typical forestry raw materials and non-timber forest products.

Teaching and Learning Methods:
Lecture, exercises, seminar, Optional: visits to laboratories and industry.

Media:
Demonstration material: raw materials and products; PP presentations; videos.

Reading List:

Responsible for Module:
Prof. Dr. Klaus Richter – Lehrstuhl für Holzwissenschaft Winzererstr. 45, 80797 München, Tel.: 089/ 2180 - 6421, richter@hfm.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
For further information in this module, please click campus.tum.de or here.
Module Description

WZ4161: Forest Management | Forest Management

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module integrates different scientific and management methods with the objective to develop concepts for the sustainable management of forest. Forest managers must understand complex content and be able to explain it to a critical audience. The learning outcome will be assessed by an oral exam (30 minutes) covering the whole outcomes of the module.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None.

Content:
1. Definition of forest and forest ecosystem
2. Overview of forestry on global, regional and local scales
3. Introduction into objectives and methods of forest ecosystem management and forest management planning
4. Demonstration of forest decision support systems and multiple-objective optimization
5. Overview of silvicultural techniques
6. Basic Knowledge of Forest economics
7. Demonstration of examples in lowland and mountain forest management.

Intended Learning Outcomes:
At the end of the module the students are able to:
- understand different concepts of forest management
- understand different demands in forest management
- apply means of linear programming to harmonize different measures
- apply decision support systems
- evaluate different forest management measures.

**Teaching and Learning Methods:**
The module is separated into lectures and exercises. Lectures providing the theoretical foundations and concepts in Forest Management. Exercises are done in supervised groups in the field.

**Media:**
PowerPoint presentations, additional reading material, software application.

**Reading List:**

**Responsible for Module:**
Felbermeier, Bernhard; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or here.
Module Description

WZ4189: Fisheries and Aquatic Conservation | Fisheries and Aquatic Conservation

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Current information regarding the limited activities with physical presence due to the CoViD19-pandemic:

In case the framework requirements (hygiene, distance rules etc.) for examinations with physical presence are not met, the planned examination format can be changed to a digital (remote) examination according to §13a APSO. The decision on this change will be communicated as soon as possible, however latest 14 days before the actual examination date, by the responsible examiner in coordination with the examinations board.

The examination consists of a 60 min. written exam (Klausur). In addition, the students need to prepare a 10-15 min. presentation in the practical exercise. Gradings from the examination and the presentation are weighted in the ratio 2:1.

The examination means to measure the student’s ability to assess anthropogenic influence on aquatic ecosystem functioning, evaluate the socioeconomic importance of fisheries and aquaculture, explain factors affecting susceptibility to and recovery from overexploitation and recall fisheries management tools for wild populations as well as of the underlying biological principles such as fish population dynamics. In the written examination students demonstrate by answering questions under time pressure and without helping material their theoretical and practical (e.g. application of methods) knowledge about fisheries management. For answering the questions, the students require their own wording.

In the practical exercise the students prepare a presentation in form of a brochure, poster, video or podcast. For the presentation, the student is expected to demonstrate that he or she is capable of preparing a certain topic within a given time frame in such a way as to present or report it in a clear and comprehensible manner to specific target audiences in the context of fisheries and aquatic conservation.
Repeat Examination:
Next semester

(Recommended) Prerequisites:
Interest in aquatic biology, social sciences, conservation biology and management; this course can be selected independently from other courses in the fields of Fish Biology and Limnology at TUM

Content:
The module combines the theoretical background and the practical implementation of fisheries management and aquatic conservation. The key aspects are:
1. Introduction to fish, shellfish and fisheries management,
2. The socioeconomic importance of fisheries and aquaculture,
3. The functioning of aquatic ecosystems and the impacts of fisheries on aquatic ecosystem health,
4. Factors affecting susceptibility to and recovery from overexploitation,
5. Fisheries Management Tools for wild populations,
6. Aquaculture,
7. Aquatic Biodiversity Conservation,
8. Case study and knowledge transfer/communication excercise

Intended Learning Outcomes:
At the end of the module students understand the importance of aquatic resources for mankind and the variables which influence ecosystem functions as well as the principles of aquatic biodiversity conservation. They are able to analyze the effects of natural and man-made disturbances in aquatic ecosystems (e.g. overexploitation) based upon an interdisciplinary understanding of methodological aquatic and fisheries biology, human dimensions, socioeconomic factors and management skills. In addition, students are able to objectively integrate knowledge from different disciplines (e.g. fish biology, conservation biology, commercial fishing techniques, aquatic habitat assessment and management) to evaluate sustainable resource management.

Teaching and Learning Methods:
The module combines a lecture "Fisheries Management" with an accompanying practical excercise "Applied Aquatic Conservation". The lecture contents will be presented using lectures based on power-point presentation, group work and interactive role plays in order to combine activating teaching methods with classic presentation techniques. In the accompanying practical excercise to the lecture the students will apply the gained theoretical knowledge by conducting case studies or participating research experiments with various content in the field of freshwater ecology and aquatic conservation. The content of the practical work is incorporated into running research projects at the chair (e.g. habitat restoration, artificial breeding programmes, habitat assessment, conservation genetics). Additionally, the students learn to independently screen the respective literature in this field and learn methods in science communication.
Media:
Form of presentation: lecture, case study, movie segment and practical exercise
material: lecture notes, flip-chart/board, plus different materials for methodological/technical training

Reading List:
1. King (2007) Fisheries Biology, Assessment and Management
2. Helfman (2007) Fish Conservation: A guide to understanding and restoring global aquatic biodiversity and fishery resources

Responsible for Module:
Geist, Jürgen; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Fisheries Management (Vorlesung, 2 SWS)
Geist J

Applied Aquatic Conservation (Übung, 2 SWS)
Geist J [L], Geist J, Pander J, Stoeckle B, Zingraff-Hamed A

For further information in this module, please click campus.tum.de or here.
## Module Description

**IN2124: Basic Mathematical Methods for Imaging and Visualization | Grundlegende Mathematische Methoden für Imaging und Visualisierung**

Version of module description: Gültig ab winterterm 2011/12

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor/Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits: *</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

**Description of Examination Method:**

Type of Assessment: written exam.

The exam takes the form of a 75-minute written test, in which the students, based on the questions posed, are intended to demonstrate their knowledge of the basic mathematical methods as well as their ability to apply those methods successfully when solving basic abstract mathematical problems. In addition, by answering questions about concrete applications in image processing and computer vision, the students are expected to show that they can formulate applied problems mathematically, that they can analyze their mathematical properties, and that they can solve them using suitable methods.

**Repeat Examination:**

End of Semester

(Recommended) Prerequisites:

IN0015 Discrete Structures, IN0018 Discrete Probability Theory, IN0019 Numerical Programming, MA0901 Linear Algebra for Informatics, MA0902 Analysis for Informatics

**Content:**

Basic and most commonly applied techniques will be presented in the lectures and demonstrated in example applications from Image Processing and Computer Vision. The same mathematical methods are also applied in other engineering disciplines such as artificial intelligence, machine learning, computer graphics, robotics etc.

The module IN2124 is covering topics such as:

- Linear Algebra
- Linear spaces and bases
++ linear mappings and matrices
++ linear equation systems, solving linear equation systems
++ least squares problems
++ eigen value problems and singular value decomposition
- Analysis
++ metric spaces and topology
++ convergence, compactness
++ continuity and differentiability in multiple dimension, taylor expansion
- Optimization
++ existence and uniqueness of minimizers, identification of minimizers
++ gradient descent, conjugate gradient
++ Newton method, fixed point iteration
- Probability theory
++ probability spaces, random variables
++ expectation and conditional expectation
++ estimators, expectation maximization method

In the exercises the participants have the opportunity to gain deeper understanding and to collect practical experience while implementing or applying the methods in order to solve real problems.

**Intended Learning Outcomes:**

Upon successful completion of the module, participants understand the basic mathematical techniques and methods. They are then able to formulate real problems in the field of imaging and visualization mathematically, and to select methods for solving the problem, to optimize them and to evaluate them. They will also be able to apply these techniques and methods to other engineering disciplines such as artificial intelligence, machine learning, computer graphics, robotics etc.

**Teaching and Learning Methods:**

The module consists of lectures and tutorial sessions. The content of the lectures is conveyed in presentations of scientific material via slides and blackboard. By solving homework assignments, the students are encouraged to work intensively on the respective topics and their applications. The solutions of the assignments are discussed in the tutorial sessions.

**Media:**

slide presentation, blackboard

**Reading List:**

MATLAB
- Cleve Moler, first chapter of Numerical Computing with MATLAB, SIAM
- Yousef Saad, Iterative Methods for Sparse Linear Systems, SIAM
- Lloyd N. Trefethen and David Bau, Numerical Linear Algebra, SIAM
- Gilbert Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press
- Walter Rudin, Real and Complex Analysis, McGraw-Hill
- Ake Björck, Numerical Methods for Least Squares Problems, SIAM
- Jonathan Shewchuk, An Introduction to the Conjugate Gradient Method Without the Agonizing Pain
- Uri Ascher, A first course in numerical methods, SIAM Probability Theory
- Heinz Bauer, Measure and Integration Theory, deGruyter
- Sheldon Ross, Introduction to probability and statistics for engineers and scientists, Elsevier
- Lloyd Nick Trefethen, Finite Difference and Spectral Methods for Ordinary and Partial Differential Equations
- Cleve Moler, chapter 11 of Numerical Computing with MATLAB, SIAM

**Responsible for Module:**
Navab, Nassir; Prof. Ph.D.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Grundlegende Mathematische Methoden für Imaging und Visualisierung (IN2124) (Vorlesung mit integrierten Übungen, 4 SWS)
Lasser T [L], Lasser T (Cheslerean-Boghiu T, Pekel E)
For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description

WZ2717: Genetic Resources Management and Forest Protection | Genetic Resources Management and Forest Protection

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcome will be assessed by a written exam (duration 60 min) where the student have to analyze the risk of given pest and abiotic hazard-scenarios and to develop adequate disturbance management strategies. Furthermore, they have to analyze a genetic diversity study from a plant, animal or fungus species and develop a long-term genetic management strategy. In this way, the students can demonstrate that they have obtained the ability to use their knowledge in real world management situations.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in biology and forest science

Content:
PPart I Genetic Resources Management – Schaefer/Benz
1. Introduction: DNA, genetic code, genes, alleles, genomes, speciation
2. Basics of Population Genetics
3. Genetic variation in forest ecosystems
4. Tree breeding
5. Genetic conservation & sampling strategies
6. GRM in mountain ecosystems
7. GRM in the Tropics
8. GRM in the dry zones
9. Sustainable management strategies
10. Fungi – The Good, the Bad, and the Ugly
11. The genetic treasure trove of fungi
Part II Disturbance ecology & management– Seidl/Seibold
1. Disturbance ecology 101 (R. Seidl)
2. The role of disturbances in forest ecosystem dynamics (R. Seidl)
3. Forest protection strategies in the course of time (S. Seibold)
4. Wind (R. Seidl)
5. Snow and ice (R. Seidl)
6. Fire (R. Seidl)
7. Drought (R. Seidl)
8. Functional roles of insects in forest ecosystems (S. Seibold)
9. Bark beetles – ecology (S. Seibold)
10. Bark beetles – management and impacts (S. Seibold)
11. Defoliators (S. Seibold)
12. Aphids, adelgids and others (S. Seibold)
13. Deadwood-inhabiting insects (S. Seibold)
14. Principles of disturbance management (R. Seidl)

Intended Learning Outcomes:
On successful completion of the module, students are able to
- assess genetic diversity patterns in natural populations of different groups of organisms (mammals, birds, plants, fungi)
- understand the importance of maximizing genetic diversity
- understand the impact of biotic and abiotic factors on vitality and stability of individual trees and forests;
- understand the impact of fungal pathogens and insects on trees;
- apply their ecological knowledge to minimize and forecast the risk of damages by fungal pathogens;
- explain the most important abiotic and biotic causes of tree death in forest ecosystems
- ccharacterize forest disturbance regimes
- understand the different roles that disturbances play in forest ecosystems
- knexplain how plants adapt to different disturbance agents
- develop different disturbance management strategies.

Teaching and Learning Methods:
Lectures and presentations: provide the theoretical population genetics and ecological background to understand the role of genetic diversity in general and the role of disturbance at population level and beyond.
Group work: will be used to learn how to assess and interpret genetic diversity patterns in various real world examples and to practice risk forecasting in disturbance management or develop disturbance management strategies.
Field trip (optional): to help understand the role of disturbance and genetic diversity in a real Bavarian forest setting.
Media:
lectures and presentations (pdfs)

Reading List:

Responsible for Module:
Schäfer, Hanno; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Genetic Resource Management (Vorlesung, 2 SWS)
Benz J, Schäfer H
Disturbance ecology and management (Vorlesung, 2 SWS)
Seidl R [L], Seidl R, Seibold S
For further information in this module, please click campus.tum.de or here.
Module Description

WZ1545: Human Resource Management in Agriculture and Related Industries | Human Resource Management in Agriculture and Related Industries

Version of module description: Gültig ab winterterm 2018/19

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
During the written exam (90 min.) students demonstrate their ability to understand human resource management practices, to select and adapt techniques suitable to specific contexts in agriculture and life science industries, to compare and contrast techniques and practices, to evaluate and change selected practices in case applications. Example practices cover the fields of planning the workforce, recruiting, selecting, and training employees, as well as providing feedback to, and evaluating employees, as well as discipline and dismissal, compensation, incentive plans, benefits and services, and workplace diversity. Students analyze exam questions and write up answers in their own words.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
BS Degree. Prior knowledge of basic ideas of economics and management is required; knowledge in strategic management is recommended.

Content:
The course is designed to provide master level students with an understanding of pertinent human resource management practices and how to adapt practices from other industries to farms, horticultural and landscaping operations, in agribusinesses, in the food industry, and in related businesses. Practices relate to planning the workforce, recruiting, selecting, and training employees, as well as providing feedback to, and evaluating employees. Additional practices relate to discipline and dismissal, compensation, incentive plans, benefits and services, and workplace diversity. Examples of current issues as well as laws and regulations provide context for different human resource management practices.
Intended Learning Outcomes:
After successfully completing the module, students are able to accomplish the following:
- understand human resource management practices and their objectives;
- evaluate human resource management practices in use;
- develop and adapt appropriate human resource management practices for specific organizations in agriculture and the life science industries.
- determine the fit of different human resource management practices with different organizational goals and environments.

Teaching and Learning Methods:
Lectures serve to introduce human resource management practices and their objectives. Video clips serve to illuminate HRM practices and as a basis of discussion of practices. Case descriptions and task sheets are analyzed in small groups and discussed in class to empower students to apply human resource management practices in specific constellations.

Media:
Presentation software, case descriptions and task sheets, discussion facilitation support media, video clips

Reading List:

Responsible for Module:
Bitsch, Vera; Prof. Dr. Dr. h.c.

Courses (Type of course, Weekly hours per semester), Instructor:
Human Resource Management in Agriculture and Related Industries (Seminar, 4 SWS)
Bitsch V [L], Bitsch V, Huhn C, Köksal S
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2731: Hydrometeorology and Management of Water Resources
Hydrometeorology and Management of Water Resources

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcome will be assessed by an oral examination (30 min) in which students should demonstrate their profound understanding of water management and ability to analyze and evaluate key issues and challenges. They should exhibit the capability of identifying and solving problems in a concise way and show that they can express themselves in a clear and scientific manner. A voluntary mid-term assignment (presentation) in the seminar assesses the students’ ability to communicate and present an integrated management study case in one selected topic in sustainable water management. It will serve for grade improvement by 0.3 according to §6(5) APSO.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in chemistry and physics.

Content:
1. Hydrometeorology (including hydrological cycles, precipitation-, run off-, evapotranspiration - process of formation, measurement, global and regional spatial and temporal patterns, influences by land use land cover change, climate change scientific basis, climate change impacts, adaptation, vulnerability in water resources).
2. Problems in water management according to too little water, too much or too dirty. Different aspects of water augmentation (e.g. harvesting, desalination, translocation), water conservation (irrigation, pricing, household, …), water management processes (e.g. IWRM, virtual water) are discussed by practical examples;
Intended Learning Outcomes:
Upon the successful completion of this module the students are able to understand the basics of hydrology, and the influence of climate change on hydrological processes and management. They are able to analyze and classify various problems in water resource management and to assess the suitability and applicability of different management practices in the field of water augmentation (e.g. rain water harvesting, fog nets, dams) and water saving strategies (e.g. in irrigation, sanitation) to integratively solve water-resource-problems.

Teaching and Learning Methods:
The basics of hydrology and meteorology are presented and discussed in a lecture with thorough explanations. Some simple case studies are used to introduce into the theoretical background (e.g. meteorological instruments at the meteorological platform). Student presentations and discussions, group work in the seminar.

Media:
PowerPoint presentations; Presentation notes supporting the lecture. Case studies.

Reading List:

Responsible for Module:
Prof. Dr. Annette Menzel - Professur für Ökoklimatologie Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, 08161/ 71-4740, amenzel@wzw.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
For further information in this module, please click campus.tum.de or here.
Module Description

EI70860: Integration of Renewable Energies | Integration of Renewable Energies [IRE]

Version of module description: Gültig ab summerterm 2020

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>German/English</td>
<td>one semester</td>
<td>winter/summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module exam consists of a written exam (60 min). The goal of the exam is to test with questions if the students are able to reproduce general challenges regarding the integration of renewable energies. With calculations on simple examples the capability of working with this general knowledge on specific questions is tested. The exam will be graded.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamental knowledge in:
- renewable energy technologies (hydro, wind, photovoltaic, biomass, geothermal)
- power generation and transportation in large quantities in future energy supply scenarios
- fossil and renewable energy carriers
- regulation frameworks in electricity markets
- political and social aspects in energy systems

Content:
The lecture is subdivided in an introduction and three main chapters (physical, system and market integration), which classify the different challenges of the integration of renewable energies in an existing electricity system:
The introduction discusses the characteristics of fluctuating power generation from renewable energies and derives the resulting challenges for the system.
Physical integration discusses (technical) options, which enable an adaption of the generation side and the demand side (grid, storage, demand side integration, etc.).
System integration evaluates the possible contribution of renewable energies to provide ancillary services (balancing power, reactive power, inertia, etc.).
Market integration explain the influence of an increasing share of renewables on the existing market participants and discusses alternative framework design options.

**Intended Learning Outcomes:**
Upon successful completion of the module, students are able to:
- describe the challenges of a power system with a high share of renewable energies
- understand the properties of renewable energies from a system perspective
- analyze possible options to improve the integration of the renewable energies
- understand the system behavior of renewable energies
- analyze the influence of renewable power generation on operation of the conventional power plant park
- assess renewable power generation in relation to electricity markets and the demand of balancing power

**Teaching and Learning Methods:**
Lecture: beamer and partly blackboard presentations with teacher centered teaching
Tutorials: Calculations (by hand or PC based) as well as reading assignments which are both discussed in lessons

Language of instruction, English in Winter Semester and German in Summer Semester.

**Media:**
Lecture and exercise with beamer and blackboard. Presentations and exercise will be presented online.

**Reading List:**
Lawrence E. Jones, Renewable Energy Integration, 2017
IEA: The Power of Transformation, 2014

**Responsible for Module:**
Hamacher, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Integration of Renewable Energies (Vorlesung mit integrierten Übungen, 4 SWS)
Kuhn P, Gawlick J
For further information in this module, please click campus.tum.de or here.
Module Description

EI7467: Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country | Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country [ProRESDC]

Interdisciplinary Student Project Concept Development of a Renewable Energy System in a Developing Country

Version of module description: Gültig ab winterterm 2016/17

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>135</td>
<td>45</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students' learning success will be determined by the following components of the project:

1. Input throughout the course of the milestone meetings (the supervisor of a team will rate each member of his team individually based on her or his input during the milestone meetings):
   - Integration of the extraneous inputs, which his team members from other fields of study give, in order to develop a holistic concept for a renewable energy system in a developing country
   - Analyzing the framework conditions, determining obstacles and deriving innovative solutions for renewable energy systems in developing countries before each milestone meeting
   - Communication with the team leader and the other team members
   - Meeting the timetable

2. Final presentation:
   A jury will evaluate, how far the team manages to transfer their developed concept into an understandable context and to convince the audience of their choice of a certain concept. This includes the logic of the presentation, the focus on relevant points and appealing visualizations of their presentation slides.
   In addition to this, each team member is individually evaluated for her or his presentation methods and expertise shown during the subsequent questions.

3. Project report (identical evaluation of all team members):
Here is rated how much convincing the decision was explained for the chosen energy concept and against other possible concepts due to the technological, financial and socio-cultural conditions and how comprehensible the implementation of the final concept was described.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
- Bachelor degree in a technical field of studies or in TUM-BWL
- Participation in "Series of lectures Renewable Energy Systems in Developing Countries"
- Interest in energy systems and their application / realization in developing countries
- Interest in the conversion of knowledge, which may differ from the field of her or his own studies on the one hand, but on the other hand is essential for the holistic understanding of their own study curriculum
- Interest in team-based project work and developing a realizeable concept
- Letter of motivation regarding study program, expertise, motivation and relevant experience (1.000 - 2.000 characters)

Content:
During the study project students develop a concept for the renewable energy system of a given location in a developing country.
During this concept development the variety of possible energy concepts will be reduced by general characteristics of stand-alone systems in the first step, followed by technological criteria in developing countries and socio-cultural impacts. Subsequently, the suitability of the various power production technologies, which are presented in the lectures, will be evaluated for the site in the developing country. Afterwards financing possibilities and framework conditions of regional market will be taken into account for the selection of the energy concept. In the end the final energy concept will be derived out of these sub steps.
Additionally the students derive options based on their developed energy concept, how to empower the population of the region economically by means of renewable energies.

Intended Learning Outcomes:
After participating in the project the students will be able to:
- understand extraneous knowledge concerning renewable energy systems in developing countries by the interdisciplinary collaboration with students from different study fields
- implement this interdisciplinary knowledge about energy systems in developing countries into action competences
- present the progress of a project target-oriented in meetings
- highlight the relevant technological, financial and sociocultural framework conditions of a planned energy system for a certain location in a developing country
- evaluate various options of energy supply concepts with based on their framework conditions
- manage the progress of a concept
- develop a suitable energy concept based on the requirements and possibilities of a defined location
- present convincingly their concept in a final presentation
- describe convincingly in a project report both the choice of their energy concept taking the involvement of all relevant aspects into account and the its realization

**Teaching and Learning Methods:**

Students are expected to achieve the learning outcomes by means of a project internship. Interdisciplinary teams of students, consisting of students from various faculties, develop a concept for a renewable energy system for a particular location in a developing country in defined milestones. Each team is advised by a scientific assistant, who is their team leader. This advisor is managing the technical expertise of the team members with her or his project experience during the weekly milestone meetings.

Finally, each team presents its energy concept in a final presentation and in a project report. As a closing event there is offered a two-day excursion to an alpine mountain hut in Tyrol. Here both the the pros and cons of the concepts developed by the students are discussed to give the students the opportunity to reflect on their own work and that of their fellow students. Also the island energy system of the alpine hut, consisting of PV, biomass and battery storage, is shown in order to experience a realization of such a low-budget energy system.

**Media:**
- Practical presentation of components using PowerPoint slides and scripts for the subsequent experiments (practical events)
- PowerPoint slides to define the milestones (milestone meetings)
- Final presentation using PowerPoint
- Project report using Word or Latex

**Reading List:**
- Engineers without Borders UK in 2014 - Engineering in Development
- Scripts for each practical event
- Other thematic literature on the recommendation of the speakers of the lecture series

**Responsible for Module:**
Hamacher, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Interdisziplinäres Projektpraktikum Konzeptentwicklung eines Erneuerbaren Energiesystems in einem Entwicklungsland (Forschungspraktikum, 4 SWS)
Hamacher T, Cadavid Isaza A, Elyasi S, Pant P
For further information in this module, please click campus.tum.de or here.
Module Description

LS50000: International Climate Strategies / UNFCCC | International Climate Strategies / UNFCCC

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>90</td>
<td>90</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
For this module, students will give a presentation (ca. 30 min, 30% of final grade), contribute to a blog (10% of final grade) about the COP conference, and submit a written term paper (ca. 15 pages, 60% of final grade).

The purpose of the presentation is to display students’ ability to conduct research independently and to present results in a professional manner, using PowerPoint or an equivalent presentation software. The blog about the COP conference will indicate students' evolving knowledge of and insights into ongoing discussions and relevant topics at the COP. In their term paper, students shall demonstrate their ability to conduct an in-depth analysis of a case study on respective climate strategies and politics and UNFCCC involvement as related to climate change adaptation, mitigation and sustainability challenges. Students have the opportunity to alternatively choose for a nation or group of actors or a thematic topic (such as climate finance or climate justice) for their written paper. They shall establish their analytical competence with regards to current problems and transdisciplinary connections between international climate politics and domestic circumstances, including available environmental resources.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
The module International Climate Strategies / UNFCCC comprises following topics:
- Climate politics as an integrative part of environmental policy
- Evolution of climate negotiations under the UNFCCC and related actors’ strategies
- UNFCCC design and processes, also practically experienced as part of an NGO observer delegation to COP negotiations
- Dynamics of international climate negotiations in times of crisis
- Interactions between country delegations and NGO observer delegations
- Climate change mitigation, adaptation, finance and loss & damage
- Climate justice
- National climate change adaptation and mitigation policies and their relation to international climate policy
- National climate policies’ embeddedness in and relations to natural environmental resources and resulting sustainability options, such as LULUCF

**Intended Learning Outcomes:**
After participating in the module, students will be able
- to identify history, key concepts, actors, their strategies, and discourses in the UNFCCC process and related national climate policy debates and be exposed to negotiation theories and tactics
- to apply methods of comparative analysis to climate politics at the national and international levels and test theoretical concepts with empirical research/field study methods
- to have a deeper understanding of different aspects of climate change politics, such as mitigation, adaptation, finance, and loss & damage
- to apprehend the political challenges and opportunities embedded in big transformations, such as the one required to address the current climate crisis
- to identify climate change related national environmental and socioeconomic factors, such as geography, natural resources, impacts and mitigation options, and to develop and understand their relationship to climate strategies of (group of) actors

**Teaching and Learning Methods:**
The module is comprised of a seminar and an excursion (either in person or online) to a UN Climate Conference (COP). Students will participate in a TUM delegation as NGO observers and attend one of the two weeks of a COP conference. Students who are unable to physically attend the COP conference will be expected to follow the conference online as the conference proceedings are live-streamed.

Two excursions will be offered of one week length each to allow as many students as possible to actively participate, pending the number of eligible places. Note: Excursion costs (flight, accommodation, food) will not be covered by TUM. It is recommended to have international health insurance. Accident insurance is provided in accordance with section VII of the German Social Security Code (SGB VII).

The seminar is divided into two parts – a preparatory pre-excursion and a follow-up post-conference debriefing and analysis. In the preparatory part, the students read relevant introductory literature on the UNFCCC and international climate science and politics. Students will prepare short presentations based on the reading materials, which will serve as the foundation for discussions with the whole group (Guided Reading). In the post-conference period, students will obtain a deeper understanding of the module’s topic through general discussion about what was learned regarding the climate negotiations and side events (as observed during the excursion or online) as well as independent/group work on concrete examples. Students will analyse, evaluate
and interlink national climate policies to the natural science of climate change and environmental sustainability as perceived in the different regions/nations or for actor groups. The students will prepare and hold related presentations and actively discuss the international context.

**Media:**
Seminar talks and discussions (both online over ZOOM and in presence), PowerPoint presentations, online blog on COP experiences, TUM Moodle, Earth Negotiations Bulletining (ENB) Newsletter

**Reading List:**
- Guri Bang, Arild Underdal, & Steinar Andresen, eds. The Domestic Politics of Global Climate Change: Key Actors in International Climate Cooperation (Cheltenham, UK 2015).
- National Communications under the United Nations Framework Convention on Climate Change.
- Repository of UN Documents

**Responsible for Module:**
Menzel, Annette; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
UNFCCC / COP Conference (Exkursion, 3 SWS)
Menzel A [L], Koppenborg F

International and National Dimensions of Climate Strategies in the Context of UNFCCC (Seminar, 3 SWS)
Menzel A [L], Koppenborg F, Menzel A, Schreurs M

For further information in this module, please click campus.tum.de or here.
Module Description

**WZ2733: Introduction to Soil Science**

Version of module description: Gültig ab summerterm 2021

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

**Description of Examination Method:**
In a written exam of 60 minutes duration, the students demonstrate by answering questions without helping material their understanding of the nature and properties of soils, and they remember the characteristics of the soils of the field course as well the field assessment methods. In a pass/fail exam (laboratory assignment) in the field of 10 minutes duration, they prove their ability to survey and interpret a soil profile.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in chemistry, physics, and biology.

**Content:**
- What is a soil?
- Mineral (inorganic) soil components
- Soil biology and soil organic matter
- Soil chemistry
- Soil physics
- Soil-forming processes
- Soil survey
- Soil interpretation
- Soil erosion assessment

**Intended Learning Outcomes:**
The students understand the basics of soil science. They can use their knowledge from soil mineralogy, soil organic matter, soil chemistry, and soil physics to understand soil formation.
processes and important biochemical and physical properties. The students are able to survey a soil profile and to detect the genesis of the surveyed soil. They can evaluate the possibilities of soil use, the risks to the soil itself and the risks to its environment. They are able to evaluate the hydrology of the soil and to judge the erosion risk.

**Teaching and Learning Methods:**
The lecture discusses the essentials of soil science. The field assessment starts with peer instructions to analyse a soil profile. During the course, the students will do more and more group work to train the evaluation of a soil profile, its hydrology and its erosion risks.

**Media:**
Lecture: presentation notes. Field Assessment: spade, auger, knife, colour charts, TDR probes, suction cups, erosion assessment kits.

**Reading List:**

**Responsible for Module:**
Schad, Peter; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click campus.tum.de or here.
Module Description

WZ4094: Landscape Management - Application Study | Landscape Management - Application Study

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>95</td>
<td>75</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

**Description of Examination Method:**

The assessment is based on a project work: 1. the participation intensity on discussions and the quality of the contributions during the courses; 2. the demonstrated skills in creating new data layers by combining existing data from official sources (administrations, organizations, etc.) using GIS techniques, in exploring new data and information layers (RS, vegetation ecology), etc. 3. the contribution in developing the project (planning competences); 4. the presentation style, contents and layout; 5. the team work; 6. the project report.

**Repeat Examination:**

Next semester

**(Recommended) Prerequisites:**

The successful completion of the modules "Inventory Methods and GIS", "Remote Sensing and Image Processing", "Geographical Information Systems and Vegetation Ecology" and "Landscape Planning" or equivalent skills are required, courses on scientific writing and reporting recommended.

**Content:**

1. Implementation of GIS and RS techniques.
2. Implementation of theoretical concepts of Vegetation Ecology;
3. Implementation of theoretical concepts of Landscape Planning;
4. Oral presentation of findings;
5. Elaboration of a final report.

**Intended Learning Outcomes:**

At the end of the module the students are able to develop or at least to contribute to a landscape management project. More in detail the students are able to:
- work in a team;
- apply the theoretical and practical skills in vegetation ecology, landscape planning, remote sensing and GIS techniques;
- contribute to context-dependent landscape-related planning;
- deliver an oral presentation to communicate their findings;
- prepare a convincing project report using supporting data to back their statements in accordance with guidelines for scientific writing.

**Teaching and Learning Methods:**
Prime characteristic of the Application Study is the self-organized group work by the students to reach the defined objective of the project assignment. Progress of the team is supported by group discussions, theory input and coaching provided by lecturers on demand.

**Media:**
Scripts and reports of the above listed lectures and exercises offered within the elective field; basic data sets to develop the application study (GIS, RS, etc.); additional information on request and up on necessity (project driven).

**Reading List:**
The literature recommended within the Modules "Inventory Methods and GIS", "Remote Sensing and Image Processing", "Geographical Information Systems and Vegetation Ecology" and "Landscape Planning" should be used.

**Responsible for Module:**
Dr. Thomas Schneider – Professur für Waldinventur und nachhaltige Nutzung Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, 08161/ 71-4666; tomi.schneider@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Landscape Management - Application Study (Vorlesung mit integrierten Übungen, 5 SWS)
Augenstein I, Döllerer M, Mengesha M, Teixeira Pinto L
For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://campus.tum.de).
Module Description

WZ2722: Mountain Catchments under Changing Climate | Mountain Catchments under Changing Climate

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a written exam, students demonstrate that they have gained an understanding of hydrological processes and that they are able to apply and run a hydrological model for a mountain catchment. By an 10min oral presentation and a 5min discussion via Live-Stream (ZOOM) the students’ ability to understand selected hydrology-related threats for mountain catchments and to scientifically analyze and evaluate important influencing factors, to present it to an audience, and to conduct a discussion about the presented subject in a clear and concise scientific manner is assessed. The final grade is an averaged grade from the presentation (65%) and the written exam (35%).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Introduction in Hydrometeorology and management of water resources.

Content:
In the Field Course Applied Hydrometeorology of Mountain Catchments we will visit selected research stations, field sites, hydrological infrastructure, restoration sites, and protected areas in the Munich PreAlpine and Alpine area and learn more about hydrology-related threats for mountain catchments ranging from Glacier melt to Munich's drinking water. Sites include e.g. Environmental Research Station Schneefernerhaus, KIT Alpine Campus Garmisch, Waldklimastation Kreuth, Sachenbach catchment, Versuchstation Obernach, Sylvensteinspeicher, Walchenseekraftwerk, Versuchsstation Wielenbach, Mangfall / Lech Wassereinzugsgebiet.

The Hydrological Modeling course includes:
1) Dominant hydrological processes in mountain catchments: Precipitation types, runoff generation, concentration and flood routing
2) Data in mountain catchments: Availability, quality, acquisition and analysis
3) Types of hydrological models
4) Generation, parameterization and calibration of the process based hydrological model WaSiM
5) Model sensitivity analyses with focus on meteorological input and land use scenarios.

**Intended Learning Outcomes:**
After completion of the module, the students understand the main processes in mountain catchments like runoff generation, runoff concentration and flood routing processes. Additionally, they are able to use a physically based hydrological model to simulate the rainfall runoff process in mountain catchments and its influencing parameters caused by the special circumstances of these regions in a widely realistic and transparent way. The students are able to generate event based scenarios as well as land use scenarios and understand recent hydrology-related threats for mountain catchments as well as the influence of climate change on hydrological processes and management in mountain areas. They remember suitable monitoring and risk prevention strategies and are able to analyze, evaluate and communicate (both oral and written) a specific case study or research questions related to the experimental sites visited to a general audience.

**Teaching and Learning Methods:**
Teaching methods include lecture as well as practical exercises at PC laboratory in respect to hydrological modelling, a week of field trip to Alpine and pre-alpine areas to the listed sites with guided tours by local scientists, administrators, TUM lectures as well as short presentations by the students.

**Media:**
PowerPoint Presentation, Hydrological model (e.g. WaSiM), Field work

**Reading List:**

**Responsible for Module:**
Responsible for Module: Prof. Dr. Annette Menzel - Professur für Ökoklimatologie Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, 08161/ 71-4740, menzel@wzw.tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
For further information in this module, please click campus.tum.de or here.
Module Description


Version of module description: Gültig ab winterterm 2018/19

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>105</td>
<td>45</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a research paper of around 12-15 pages which is the means to evaluate whether the students have understood and whether they are able to apply the methodology of material flow management on a case study in a scientifically manner and to create an own scientific paper about concepts for material flow management and treatment of materials based on the methodologies of material flow analysis and life cycle assessment. management and treatment of materials based on the methodologies of material flow analysis and life cycle assessment.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
knowledge in natural science (biology, chemistry, ecology, physics); understanding for engineering science and also for social/cultural aspects.

Content:
The students acquire detailed and differentiated knowledge about the following topics:
- need of material flow management
- procedure of material flow management
- material and substance flow analysis
- material flow assessment by sustainability indicators
- life cycle assessment
- development of strategies and measures for material flow management (e.g. resource efficiency, urban mining, industrial ecology, bio-economy, circular economy).
Intended Learning Outcomes:
By the means of the module the students are able to:
- understand the necessity of material flow management
- understand the relationships between different processes, technological treatments of materials and organizational measures
- apply the procedure of material and substance flow analysis
- apply the assessment methods of indicator systems and life cycle assessment
- create concepts for material flow management and treatment of materials.

Teaching and Learning Methods:
Concerning teaching methods, lecture and presentation parts provide the theoretical foundation of materials flow management. Real case studies are introduced to the students and worked out in the class. Likewise within interdisciplinary projects in reality, the students have to define and to solve problems collaboratively in group work by studying specialist literature and data sources. At the end they have to create a research paper as homework about this topic. The students are supervised by tutorials by the lecturer.

Media:
Power point presentation, lecture sheets, case studies of material and substance flow analysis and life cycle assessment.

Reading List:

Responsible for Module:
Prof. Dr. Gabriele Weber-Blaschke - Lehrstuhl für Holzwissenschaft Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising; 08161/71- 5635; weber-blaschke@hfm.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
For further information in this module, please click campus.tum.de or here.
Module Description

BGU38023: Engineered Natural Treatment Systems | Natürliche Aufbereitungsverfahren

Version of module description: Gültig ab winterterm 2016/17

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>90</td>
<td>60</td>
<td>30</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The proof of performance will be made in the form of a 60-minute written exam. The aim of the written exam is to prove understanding of basics and mechanisms of natural treatment systems and the ability to plan and design simple systems based on natural treatment processes by using existing guidelines. The answers mostly require partly own formulations, but also ticking given single or multiple answers and short calculations will be required. For the exam no aids are permitted except for a non-programmable calculator. The examiner will provide additional documents if needed for the exam.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Water and Wastewater Treatment Engineering

Content:
This module deals with processes and application of engineered natural treatment systems. Major abiotic and microbial transformation processes will be discussed in general and with respect to different applications including vertical flow and horizontal flow constructed wetlands, bank filtration and different applications of managed aquifer recharge technology. In addition, students will learn basics on enzymatic processes and reactions. The module also comprises engineering aspects for design and operation of engineered natural treatment systems as well as contents from ongoing research towards optimization of these systems and combinations with other treatment processes for water reuse.

Intended Learning Outcomes:
Upon successful completion of this module, students are able
• To describe major mechanisms and key parameters for contaminant removal in natural treatment systems
• To explain microbial and enzymatic processes and their dynamics in natural treatment systems
• To outline design of wastewater treatment with constructed wetlands for small communities based on local parameters
• To characterize methods and applications of bank filtration and groundwater recharge and discuss their potential for application in future water concepts

Teaching and Learning Methods:
Lehr- und Lernmethoden:
The module will be taught as a seminar by explaining major content in form of short lectures with integrated discussion. Furthermore, students will work in groups to develop solutions for selected case studies within the seminar. Additional field trips will help to further understand learned contents.

Media:
Presentation, group work

Reading List:
Will be announced at the beginning of the course.

Responsible for Module:
Hübner, Uwe (u.huebner@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Natürliche Aufbereitungsverfahren (Seminar, 2 SWS)
Hübner U [L], Hübner U
For further information in this module, please click campus.tum.de or here.
Module Description

ED160017: Sustainable Manufacturing | Nachhaltige Produktion [SuM]

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>German/English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:</th>
<th>Total Hours: 150</th>
<th>Self-study Hours: 105</th>
<th>Contact Hours: 45</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination is held as a written exam (90 min) in order to be able to check the learning outcomes achieved by means of short and comprehension questions as well as complex application examples and calculation tasks. A non-programmable calculator can be used as an aid. The students calculate, among other things, various technically and economically relevant sustainability variables and parameters on the basis of given practical examples. Thus the learning outcomes examined include basic aspects on awareness of the need for sustainable production, sustainability in the context of production, the holistic view of sustainability, manufacturing engineering measures, as well as assessment and measurement and standardisation of sustainability in production. In addition, the topics of sustainable design and use of products, energy and resource efficiency in production, social sustainability in production, data-based sustainability assessment in production and industrial circular economy are examined.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of the basics of production and related areas (logistics, product development, etc.) is recommended but not mandatory.

Content:
The module covers all relevant aspects regarding the topic “sustainable manufacturing” including a general overview, ways of assessing sustainability and methods to improve sustainability in an industrial context.

Lecture units:
• Sense of urgency: Why do we need to act now?
• Sustainability in the context of manufacturing
• Thinking sustainability holistically
• Manufacturing technology measures
• Evaluate, measure and standardize sustainability in manufacturing
• Sustainable design and use of products
• Energy and resource efficiency in production
• Social sustainability in production
• Data-based sustainability assessment for manufacturing
• Industrial circular economy

The module also includes exercise units, e.g. how to conduct an LCA, how to follow ISO 14001 for sustainability assessments, practical exercise on system thinking, group activity (develop suggestions for improvement of sustainability for an exemplary company).

**Intended Learning Outcomes:**
After attending the module, students can understand the importance of addressing the topic of sustainability, understand the fundamentals of sustainable manufacturing, evaluate the possible technical lever in a production that can be addressed to increase sustainability, analyze products regarding the potentials for being produced more sustainably, apply the concept of system thinking on sustainable manufacturing, and apply methods to measure sustainability.

**Teaching and Learning Methods:**
The module takes place in the form of a lecture and an exercise. In the lecture, the basics of sustainable production are explained using PowerPoint presentations. The basics of sustainable production are deepened by means of use cases, expert presentations and practical application examples. In this way, participants learn, for example, how to carry out a life cycle assessment, how to follow the standards of ISO 14001 for sustainability assessments, or how to use systems thinking to find solutions. The lecture is rounded off by guest lectures from industry in order to give students an insight into current industrial issues relating to sustainability in production.

In the exercise, the methods and concepts learned in the lecture are applied to concrete examples. The participants can create solution concepts directly with the exercise instructor and thus apply what they have learned directly to industrial or academic practical examples. They thus learn, for example, how energy and resource efficiency in production can be increased, how social sustainability in production can be integrated into production management, or which measures need to be taken for data-based sustainability assessment in production.

**Media:**
Presentations, Videos, Additional Literature

**Reading List:**
• DIN EN ISO 14040: Umweltmanagement – Ökobilanz – Grundsätze und Rahmenbedingungen
• DIN EN ISO 14001: Umweltmanagementsysteme – Anforderungen mit Anleitung zur Anwendung

**Responsible for Module:**
Zäh, Michael; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainable Manufacturing - Exercise (Übung, 1 SWS)
Zäh M, Paul M, Schneider D

Sustainable Manufacturing (Vorlesung, 2 SWS)
Zäh M, Paul M, Schneider D

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://www.example.com).
Module Description

WI001215: Network and stakeholder analysis: Sustainable resource use and agri-food system | Network and stakeholder analysis: Sustainable resource use and agri-food system

Version of module description: Gültig ab winterterm 2019/20

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
There will be a 120-minute written exam. A written exam is necessary in order to assess the holistic understanding and analytical competencies of the students. In the exam, students will describe, discuss and analyze the concepts, dimensions and methodological approaches related to network and stakeholders in sustainable resource management and agri-food sector.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in cooperation and sustainability

Content:
The module deals with the theoretical concepts, methodologies and measurement indicators and approaches of networks and stakeholders for sustainable resource management and agri-food system. Specific topics include the following:

• Network and stakeholder theories and concepts to understand, describe and explain the structure, characteristics, interactions among networks and stakeholders

• Concepts and approaches to examine network and stakeholder compositions, engagements, conflicts and influences in designing and implementing strategic decisions related to sustainable innovation, resource management and agri-food system.

• Types, levels and extents of risk associated with stakeholder engagement in implementing sustainability related projects and programs
Specific methodological approaches, tools and indicators to evaluate and prioritize the performances, outcomes and implications of different network and stakeholder constellations.

Other relevant current network and stakeholder issues in sustainable innovation, resource management and agri-food system.

**Intended Learning Outcomes:**
After completing the module, students are able to
- understand the theories, concepts, principles and frameworks underlying network and stakeholder issues, influences and collaborations for sustainable innovation, resource management and agri-food system
- apply relevant techniques and tools for describing social, economic, environmental and institutional contexts of network and stakeholder management and engagement policies and strategies towards achieving specific sustainable goals.
- analyze types, levels and extent of risks associated with stakeholder engagement and commitment in implementing sustainability related projects and programs
- critically assess and evaluate the structure, characteristics, and impacts of various forms of networks and stakeholder groups on the outcomes of sustainable resource management, innovation and agri-food system.

**Teaching and Learning Methods:**
The module includes lectures, individual and group exercises, reading assignments, and presentations. The lectures will provide theoretical and conceptual basis. Individual and team exercises will be used to analyze and discuss specific network and stakeholder issues and their solutions.

**Media:**
Präsentationen, Fallbeschreibungen, Skripte

**Reading List:**


The list will be expanded and updated using other thematically relevant books, journal articles and periodical newsletters and others.

**Responsible for Module:**
Abate Kassa, Getachew; Dr. rer. hort.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click campus.tum.de or here.
Module Description

WZ2719: Landscape Planning | Landscape Planning

Version of module description: Gültig ab summerterm 2021

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The attainment of learning outcomes for the module will be assessed in a piece of research paper of around 10 pages in which students work independently on complex issues of contemporary landscape planning demonstrating their breadth of understanding in drawing out implications of their findings and putting them into a broader context. The written assignment is complemented by a presentation and/or a colloquium of around 30 min for assessing the capacity of the students to communicate their findings orally to an audience. Depending on the number of participants, research paper and accompanying talk may be prepared either individually or in groups.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic understanding of environmental systems; Module WZ2713 Methods of Scientific Communication. For the LP seminar, class discussion is a core element. Therefore, students are expected to take part and contribute to the discourse.

Content:
Concerned with the stewardship and enhancement of environmental systems, Landscape Planning is the key planning instrument for nature conservation and landscape management in Germany. The module introduces Landscape Planning and reflects on its potential contribution to sustainable land use with a focus on non-urban areas.
Course 1: Lectures will address the guiding principles, formal instruments and procedural elements of Landscape Planning; present methodological approaches for the assessment of landscape functions and ecosystem services including methods and tools for data collection, analysis and evaluation; illustrate target formulation and implementation strategies with examples from the planning practice.
Course 2: The seminar gives students the opportunity to deepen their knowledge by reflecting on readings and planning documents as well as by discussing in class such topics as: contemporary and emerging scientific theories and methodological approaches relevant for environmental planning; rationale of stakeholder involvement; context-dependency of spatial planning; comparison of current jurisdictional and institutional arrangements on landscape-related planning in the home countries of the students and their implications.

**Intended Learning Outcomes:**
Upon completion of the module, students are able to:
- recognize the purpose and objectives of Landscape Planning;
- explain instruments and procedural elements of contemporary Landscape Planning;
- select appropriate methods and tools to assess landscape functions and ecosystem services;
- be aware of the role of Landscape Planning in the decision-making upon the use of land;
- retrieve and interpret information from different sources;
- communicate key concepts relevant for environmental planning (both written and oral).

**Teaching and Learning Methods:**
Lectures provide subject specific knowledge; class discussions of selected readings engage students in critical thinking; in group work activities students experience the application of selected methods and tools.

**Media:**
Lectures, presentations, class discussions, small group exercises, assigned readings.

**Reading List:**

**Responsible for Module:**
Dr. Isabel Augenstein i.augenstein@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
For further information in this module, please click campus.tum.de or here.
Module Description

EI74831: Project Lab Renewable and Sustainable Energy Systems | Project Lab Renewable and Sustainable Energy Systems [PropENS]

Version of module description: Gültig ab winterterm 2018/19

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>German/English</td>
<td>one semester</td>
<td>winter/summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Participants of the Project Lab Renewable and Sustainable Energy Systems should carry out analyses, planning and applications about renewable energy systems and their modelling. A team of 3-5 students should achieve a goal defined for the group over the duration of the lecture period of the semester within the framework of the project work. The problem definition, role distribution, idea development as well as the choice of suitable instruments, implementation and documentation are to be developed essentially independently by the group. The essential aspects of the work within the framework of the project internship (e.g. essential scientific contents, the treatment of a task as a completed project, division of the task among the group members) should be documented in a written report (volume: 15-20 pages).
In a supplementary presentation, the competence of the students to present their work in a structured way in a small seminar in front of an audience consisting of staff members of the chair and students will be examined. Overall, competencies in project work in the team as well as in documentation and presentation of the work should be demonstrated. The report is included in the grade with 40 %, the presentation and the cooperation in the team with 30%.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge about:
- Power systems
- Renewable energies (potentials, technologies)
- Matlab / Simulink
Content:
These are research-related and practice-oriented tasks whose topics are in line with the current research areas of the chair, such as:
- Modeling, simulation and / or regulation of energy systems
- Investigation of the potential of renewable energies
- Analysis and generation of data for energy systems
- Evaluation and interpretation of model results
- Planning and installation of plants for the use of renewable energies on the Campus Garching

Intended Learning Outcomes:
After successfully completing the module, the student is - depending on the topic - able to:
- recognize challenges of integrating renewable energies,
- apply and implement appropriate tools and methods to analyze, plan or regulate energy systems,
- interpret and evaluate results from applied models.

Teaching and Learning Methods:
Project tasks are carried out individually or preferably in groups of 2-4 students. In the process, self-dependence respectively teamwork is supported in the processing of a project task. Depending on the topic, a literature research may be necessary. The main part of the project internship, however, is the computer-aided development of analysis and evaluation tools or the planning and execution of laboratory tests or installations.
The participants will finally have the opportunity to practice preparing and holding presentations.

Media:
- Application of various programs or programming languages (Matlab / Simulink, Python, etc.)
- Test benches (renewable energy conversion plants, real-time simulator, measuring instruments)
- Presentations

Reading List:


**Responsible for Module:**
Hamacher, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Projektpraktikum Erneuerbare und Nachhaltige Energiesysteme (Forschungspraktikum, 4 SWS)
For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://example.com).
Module Description

WI001205: People in Organizations: Managing Change and Sustainability in Agribusiness and the Food Industry

Version of module description: Gültig ab winterterm 2018/19

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment type for the module is a graded report (100%). The report includes memorandums addressing 9-10 of the case studies discussed in class; and a concept paper addressing an organizational concept. The concept paper is also presented by each student. Through the case memorandums, the students demonstrate the ability to discuss the assigned case questions by selecting and applying suitable theoretical concepts to agribusiness and the food industry. Building on the reflection process for each individual memorandum and the cases, which build on each other, deep-level contextual learning is achieved. In the concept paper, students demonstrate their ability to research and critically evaluate a current organizational concept. Through the presentation and discussion of the concept paper, students demonstrate their ability to communicate theoretical concepts and their application to agribusiness and the food industry.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
This is an advanced module. Prior knowledge of economic and management concepts is required. Successful completion of a management course on MSc. level is required, e.g., Human Resource Management in Agriculture and Related Industries or Agribusiness Management. Experience in desk research and scientific writing is required. Knowledge of basic concepts of human resource management and management skills is required.
Content:
The module builds on key concepts of economics and management, specifically human resource management, to provide master level students with knowledge in organizational behavior, theory, and development and build competencies in organizational analysis and change. Topics covered include:
- metaphors of and perspectives on organizations, their strengths and limitations
- the role of the individual, the group, and the organization in a high performance environment
- organizational structures and the organization-environment fit
- corporate social responsibility, sustainability challenges, business ethics, and ethical conduct in bio-based industries
- adapting to current challenges and changes in the institutional environment of agriculture and the food industry
- understanding organizational change, facilitating change processes, and overcoming barriers in the context of agribusiness and the food industry.

Intended Learning Outcomes:
After successfully completing the module students are able to analyze, evaluate, and change organizational management and development practices in the agribusiness and food industry context. Specifically, students are able to
- select and apply suitable theoretical concepts or models of organizational behavior, theory, and development to meet organizational challenges in agribusiness and the food industry
- contrast the strengths and limitations of different perspectives on organizations
- evaluate the potential impacts of various organizational management options on the individual, group, and organizational levels
- identify ethical challenges and options to organizations in agribusiness and the food industry
- adapt organizational practices and policies to sustainability measurement requirements and develop organizational sustainability or CSR (corporate social responsibility) policies
- structure organizational change processes, apply models of organizational change, and evaluate a model's potential implications
- adapt organizational management and development practices to the specific context in agribusiness and the food industry.

Teaching and Learning Methods:
The course People in Organizations: Managing Change and Sustainability in Agribusiness and the Food Industry has a seminar format based on the case study method. The seminar format is implemented based on case descriptions of problems, challenges, and innovations in agribusiness and food industry supply chains. Through individual document research and individually prepared class discussions and group work, students develop the ability to critically reflect on and apply concepts of organizational behavior, theory, and development in the context of agribusiness and the food industry. Through presentations and concept discussions, students develop in-depth knowledge of exemplary theoretical concepts. During class discussions and group presentations, students reflect on their experiences, prior knowledge, and assignments to develop their conceptual and evaluative skills and to adapt theoretical knowledge to practical challenges.
Media:
Reading assignments; case descriptions; presentation software; discussion facilitation support media, such as flipcharts and discussion boards; video clips and podcasts.

Reading List:
Selected chapters from

Responsible for Module:
Vera Bitsch bitsch@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
For further information in this module, please click campus.tum.de or here.
Module Description

WZ4082: Plantation Forestry and Agroforestry | Plantation Forestry and Agroforestry

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The learning outcomes are assessed by an oral examination (30 min). Based on specific problem statements the students have to demonstrate their ability to analyze and assess the situation, to understand the origin of the problem and to propose solutions adapted from the methodologies and techniques procured in the course.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
Plantation forestry: Background, Definitions, Plantations in the Context of International Forest Policy, Plantation Forestry Purposes, Plantation Silviculture, Management and Economics; Agroforestry (AF): Introduction (global land-use problems, definitions, terminology), Traditional AF Systems, Environmental, economic and socio-cultural aspects of AF, Interactions in AF systems, Important tree groups in AF (NFT’s, MPT’s, Palms), Planning in AF, Legal aspects Forest Management for Carbon Sequestration: Role of forests in the global carbon cycle, Possible impacts of climate change on forests, International climate policy, Forest in the Kyoto Protocol (KP), Flexible mechanisms of the KP, REDD and REDD+, Forest management options, Modelling forest sequestration with CO2FIX, Case studies.

Intended Learning Outcomes:
Students will be able to
- understand and evaluate the major issues of plantations in the context of international forest policy,
- explain the fundamental purposes of Plantation Forestry,
- properly deploy the essential techniques of Plantation Silviculture, e.g. for establishment, tending and maintenance
- critically examine plantation projects (management, work volume, economic results).
- understand the fundamental principles and practices of agroforestry land use,
- analyze the interactions among different components of an AF system,
- assess the ecological and economic effects of AF-systems and develop adequate management options,
- address problems in the context of rural development and identify AF-based solutions
- understand the role of forests and forest management activities in the global C-cycle,
- assess forest management options for different purposes within the framework of the international climate policy,
- identify and develop concepts for mitigation projects.

**Teaching and Learning Methods:**
Knowledge and skills are imparted by lectures, group discussions, presentation of case studies and small exercises; the learning methods are learning, reviewing scientific articles, and research reference articles. The lectures will provide theories and basic reference materials which will be deepened and proved by reviewing articles. The achieved skills will be used to develop and discuss solutions for specified problems.

**Media:**
PowerPoint presentations, case studies, additional reading material

**Reading List:**

**Responsible for Module:**
Annighöfer, Peter; Prof. Dr.
Courses (Type of course, Weekly hours per semester), Instructor:
Plantation Forestry (Vorlesung, 2 SWS)
Annighöfer P [L], Annighöfer P

Agroforestry and Forest Management for Carbon Sequestration (Vorlesung, 2 SWS)
Annighöfer P [L], Annighöfer P, Thom D
For further information in this module, please click campus.tum.de or here.
Module Description

WZ4197: Protected Areas Biodiversity and Management

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Final written examination of 90 minutes in the field of protected areas biodiversity and its management to examine whether the students have understood the problematic of securing biodiversity in protected areas and are able to verify conservation measurements.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Successful completion of the 1st semester of the Master Program Sustainable Resource Management is recommended

Content:
Biodiversity and protected areas: A worldwide survey on ecozones and altitudinal belts of the world as carriers of natural biodiversity; protection of biological units; IUCN protected areas classification, the European FFH Directive as an example of a continent-wide tool for nature protection.

Habitat analysis and management: Habitat types, tools for protecting habitats, design of management plans, visitor management, best practice examples in sustainable biodiversity and habitat protection.

Intended Learning Outcomes:
On successful completion of the module students are able to:
- to put ecosystems and its utilisation options as well as its threats into a global perspective
- give clear options for further management, both regarding utilisation and protection
Teaching and Learning Methods:
Lecture, case studies, practical experiments / demonstrations, discussions.

Media:
PowerPoint Presentation.

Reading List:

Responsible for Module:
Prof. Dr. Ralph Kühn; kuehn@wzw.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Module Description

WZ4202: Political and Social Perspectives of Renewable Resources | Political and Social Perspectives of Renewable Resources

Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>105</td>
<td>45</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Oral presentation of the group project work, review paper for a scientific journal. The learning outcomes are assessed by a group project work concerning a selected topic related to the political and social perspectives of renewable resources. Therefore students have to prepare a scientific paper for an international journal of their choice and give a short oral presentation about the work done for the paper, similar to what would be expected in a 15 minute conference presentation.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of sustainable resources (materials and energy). Scientific writing.

Content:
In the lectures a number of examples of societal aspects of Sustainable Resource programs will be presented and discussed. Backgrounds are global developments such as urbanization, the rise of countries like China and India, resource availability and technological developments. Case studies deal with tropical forestry and pros and cons of tropical hardwood uses, urban planning, vernacular architecture and the use of renewable resources. We take a tour around the world and look at social housing programs in Europe, Brazil and South-East Asia. Furthermore we look at successes and failures in the German/European energy policies in comparison to the United States.

Intended Learning Outcomes:
After this course, students should be able to:
1. Develop SR stimulation programs on country or regional level and priority analysis of renewable resource applications
2. Assess priorities for development and application of renewable resources in countries with different levels of development
3. Critically analyze existing SR programs taking into account social values of stakeholders,
4. Assess impacts of global developments such as urbanization and UN-policies on SR.

**Teaching and Learning Methods:**
Discussion and creativity sessions. Project work evolving in a scientific paper for a journal of choice. Oral presentation.

**Media:**
Lectures, UN-policy notes, Discussion and Creativity sessions.

**Reading List:**
Tba

**Responsible for Module:**
van de Kuilen, Jan Willem; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Political and Social Perspectives of Renewable Resources (Vorlesung, 4 SWS)
vande Kuilen J [L], van de Kuilen J, Khaloian Sarnaghi A

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description

LS10003: Remote Sensing of Agriculture and Vegetation | Remote Sensing of Agriculture and Vegetation

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module assessment is based on a written report (10 pages - A4 single line excluding references; 70% of grade) in combination with a presentation (15 min; 30% of grade). In the report, the students design a strategy of applying remote sensing to gain insights into improving decision making for solving practical problems (e.g., food security, overuse of agrichemicals, biodiversity) in agricultural and vegetation systems.

The students are examined based on the extent to which they are able to:
- situate the problems and strategy in a relevant context
- describe the start of the art and knowledge gaps in the relevant field
- demonstrate deep understanding on methodology
- break down the strategy into workable tasks
- discuss the strategy critically from interdisciplinary perspectives
- show communicative competence

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in agricultural engineering is an advantage

Content:
Remote sensing provides a versatile tool for earth observation and environmental informatics from varied spatial and temporal scales. This module explores the potential and the future trend of the state-of-the-art remote sensing techniques in facilitating the understanding on as well as decision making in agricultural and vegetation systems. We will discuss the fundamentals of remote sensing science, including but not limited the topics below:
- Biophysical-spectral models (e.g., electromagnetic radiation (EMR), radiative transfer, spectral feature extraction, chlorophyll fluorescence);
- Sensor systems (e.g., satellite, drone) and spectral-radiometric measurements;
- Image processing and pattern recognition (e.g., classification, time-series)
- Applications in agriculture and ecology (e.g., crop stress, productivity and biodiversity monitoring)

Through integrated exercise, the students will learn about innovative methods of remote sensing and the use of remote sensing in interdisciplinary fields of agricultural and environmental sciences.

**Intended Learning Outcomes:**
Upon successful completion of this module, students are able to:
- Understand the important aspects of remote sensing;
- Relate the technologies to research questions and practical problems in other disciplines;
- Apply innovative concepts and methods to agricultural and vegetation systems;
- Evaluate the feasibility of remote sensing from the perspectives of agriculture and ecology;
- Develop a strategy of integrating remote sensing with domain knowledge for decision making in agricultural and vegetation systems;
- Communicate their strategy with good understanding and evidence.

**Teaching and Learning Methods:**
- This module combines lectures, guest seminars, field trips and computer exercises.
- The teaching content will be organized by topics instructed in both theoretical (e.g., seminar) and practical ways (e.g., hands-on demonstrations, computer programing).
- The students will learn the important concepts and methods of remote sensing, as well as the applications in addressing environmental and societal problems, in a highly interactive manner, e.g., discussion in seminars, collaborations in exercises.

**Media:**
- Present and virtual lectures
- PowerPoint, instruction manuals, scripts and codes;
- Field and lab hands-on demonstrations;

**Reading List:**
Literature will be provided according to individual topics and events.

**Responsible for Module:**
Yu, Kang; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Remote Sensing of Agriculture and Vegetation (Vorlesung mit integrierten Übungen, 4 SWS)
Yu K [L], Yu K, Camenzind M, Mokhtari A
For further information in this module, please click campus.tum.de or here.
Module Description

LS10004: Research Project ‘Smart Agriculture’ | Research Project ‘Smart Agriculture’

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter/summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>300</td>
<td>150</td>
<td>150</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module assessment is based on a report (15 pages – A4 single line excluding references; 70% of grade) in combination with a presentation (15 min; 30% of grade). The students usually hand in the report and do the oral presentation in 4 weeks after the practical work has been concluded.

The grade of the written report is based on:
1) the description of the theoretical background, research questions and objectives of the project (20%);
2) the proper description and use of methods, including statistical analysis (20%);
3) the accuracy and correctness of the results, results interpretation and discussion (30%);
4) the quality of presentation formats (e.g., tables, figures) (10%);
5) the overall structure and quality (20%), particularly examines whether the report is situated and summarized in a concise and coherent manner, in the relevant context of the research area.

The grade of the oral presentation is based on:
1) The explanation of the background, state of the art, research questions/ hypothesis (30%)
2) The accuracy and correctness of methods, data and results interpretation (40%)
3) The relevance and rigor of discussion (20%)
4) The presentation quality and skills, e.g., powerpoint format and clarity (10%)

Repeat Examination:
Next semester

(Recommended) Prerequisites:
It is recommend to take the course ‘Remote Sensing of Agriculture and Vegetation’
Basic knowledge in plant and soil sciences, agricultural engineering and remote sensing is an advantage
Basic programing skills (e.g., R, Matlab, Python) will be an big advantage

Content:
Smart Agriculture or precision agriculture is considered as a high-tech and interdisciplinary field. Students will learn how to apply and combine multidisciplinary technologies, including but not limited to, field survey, lab biochemical analysis, phenotyping, remote sensing, image analysis and AI techniques to characterize plant traits and their responses to the environment and stresses (e.g., drought). Through specific research questions and objectives, students will explore the potential and limitations of applying the new technologies to solve practical problems, e.g., in the following categories:

- Using unmanned aerial vehicles (UAV) based images (e.g., RGB, multispectral) for high throughput analysis of crop traits (e.g., height, chlorophyll), and for yield estimation and weed detection.
- Using satellite remote sensing images to monitor the spatiotemporal variability in crop health (e.g., nitrogen, water status), biomass and yield in response to environmental and climate changes.
- Correlating leaf and plant optical properties to stresses (e.g., drought) and explaining plant phenotypic and genotypic variations with the aid of hyperspectral data and radiative transfer models.
- Mapping soil spatial variability based on proximal- and remote sensing of soil physical and chemical properties using hyperspectral and multispectral data.
- Applying machine learning (ML) and deep learning (DL) to analyze satellite remote sensing data for crop type and area mapping;
- Applying ML and DL methods to analyze plant images (e.g., UAV) to detect specific objects (e.g., flowers, wheat ears) as a proxy of seed germination, plant health, productivity and biodiversity.

Intended Learning Outcomes:
Upon successful completion of this module, students will be able to:
- understand the theoretical background knowledge related to smart agriculture;
- define research questions for their selected topics in the related research area;
- apply sensor and imaging techniques for data collection in the field and laboratory;
- acquire computational and artificial intelligence (AI) skills for big data handling and data evaluation;
- interpret the results of statistical analysis and machine learning models;
- present the research findings in a concise manner in written and oral form;
- gain competence in applying proximal- and remote sensing, and AI technologies in precision agriculture.

Teaching and Learning Methods:
- The students conduct a semester (normally three months) research project. The schedule of field or lab work can be adjusted according to the student's curriculum.
- Three to five students team up as a group and define the research topic and proposal through discussion with the lecturer.
- The lecturer teach students through theoretical (e.g., seminar) and practical instructions (e.g., hands-on demonstrations, computer exercises).
- Students conduct the project through teamwork (3-5) and collaborations with doctoral students.
- Periodic meeting with the supervisor to discuss the progress of project.
- Journal club discussing related scientific articles with the lecturer and peers.
- Seminars to present project output and exchange with fellow students.

**Media:**
- PowerPoint, instruction manuals, scripts and codes;
- Field and lab hands-on demonstrations;
- TUM-Moodle, Zoom

**Reading List:**
Literature will be provided according to individual projects.

**Responsible for Module:**
Yu, Kang; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Research Project ‘Smart Agriculture’ (Projekt, 10 SWS)
Yu K [L], Yu K, Camenzind M, Mokhtari A
For further information in this module, please click [campus.tum.de](http://campus.tum.de) or here.
Module Description

LS10007: Remediation of Contaminated Sites – Lecture and Seminar

Version of module description: Gültig ab summerterm 2022

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The type of assessment of the module will take the form of a Klausur and a Presentation, each of which will count for 50% of the final grade.
The competences acquired in the lecture are subject of a written exam (Klausur 60 min, max. 20 points, no supporting materials), where the students demonstrate their ability to identify problems and find solution strategies. In the seminar, the students prove with an oral presentation (20-30 minutes, max. 10 points) their ability to analyze selected case studies about contaminated sites, to develop remediation concepts and to explain their understanding to their fellow students demonstrating their communication skills in front of an audience. The presentation is accompanied by an essay (6-8 pages, max. 10 points).
The points of both the Klausur and Presentation are summed up and converted to the final module grade according to a linear system (50 % = 4.0; 100 % = 1.0).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge in natural sciences (chemistry, physics and biology) is necessary. The module "Introduction to Soil Science" (also parallel in the same semester) is recommended.

Content:
Lecture: Bundesbodenschutzgesetz (Federal Soil Protection Act), investigation of contaminated sites, sector-specific contaminations, assessment of contaminants, risk potential, ecotoxicological tests, investigation methods, sampling strategies, analyses, remediation objectives, decontamination procedures, rehabilitation and remediation procedures.
Seminar: Investigation and remediation of contaminated sites by means of selected case studies...
Intended Learning Outcomes:
After attending the lecture, the students are able to understand legal regulations dealing with contaminated sites. They know adequate procedures for the investigation of contaminated sites and suspected contaminated sites as well as for the remediation of contaminated sites. They are able to evaluate the hazard potential of a contaminated site in terms of pollutant type and emission pathway and understand the different investigation methods. After attending the seminar, the students are able to analyze studies about contaminated sites, to prepare remediation concepts and to evaluate applied remediation measures.

Teaching and Learning Methods:
Manifold site contaminations occur in our environment and plenty different remediation methods exist. The overview is best given in a lecture. Professionals working in soil remediation must thoroughly understand a specific contamination problem and develop individual remediation plans. This is the purpose of the seminar, where students work independently and in groups, and then present and discuss the results.

Media:
Presentations

Reading List:
Lecture: presentation notes
Seminar: bibliographies to the seminar topics

Responsible for Module:
Bucka, Franziska, M.Sc. franziska.bucka@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
For further information in this module, please click campus.tum.de or here.
Module Description

LS20016: Rhizosphere Research | Rhizosphere Research

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
This module is graded, and students are asked to give a seminar presentation complemented by the submission of an extended summary on a selected topic to demonstrate a solid understanding of topics discussed in the lectures. The oral presentation is expected to be 15 min presentation followed by a subsequent 30 min discussion to demonstrate that he or she is able to respond competently to any questions, suggestions, or discussions brought by the audience and relating to his or her subject area. The extended summary is expected to be a minimum of 5 pages and will be graded. Students will be informed about the grading criteria of their extended summary during the lecture via a template. The presentation will be scheduled within the last three weeks of the semester. The extended summary should be submitted by the end of the semester.

In addition, there is the option of taking a voluntary mid-term assignment as coursework in accordance with APSO §6, 5. For this, an oral examination (30 min) has to be given. The oral exam targets the learning outcomes of the lecture of Soil Biophysics. The module grade can be improved by 0.3 by passing the course work if this better characterizes the student's performance level based on the overall impression and the deviation has no influence on passing the examination. No repeat date is offered for the mid-term performance. Successfully passed mid-term assignments will be considered when retaking a failed module examination at the next possible examination date.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Content:
The scope of this module is to learn fundamental biophysical processes taking place at the root zone and particularly at the root-soil interface and their emerging impacts on water and nutrient exchange between the soil-plant-atmosphere continuum. In this module, we will discuss the basic principles of soil physics in the context of water and nutrient transport within soils and plant roots. The particular attention is to learn why, when, and where soil physics plays an important role in water and nutrient transport across the soil-plant-atmosphere continuum.

Intended Learning Outcomes:
This module aims to enable students:
1) To mechanistically describe the theories of water and nutrients retention and transport across the soil-plant-atmosphere continuum
2) To mechanistically discuss why and when plant access to soil resources is limited in different soils and how plants may deal with these limitations
3) To evaluate the potential roles of different belowground traits (soil and plants) in improving plant access to limited soil resources under different conditions
4) To explore the state-of-the-art search in the field of soil-plant interactions and rhizosphere

Teaching and Learning Methods:
This module consists of two parts:
1) Lecture on Soil Biophysics: In weekly lectures, students will be introduced to the principle of water and nutrient transport within porose media, such as the soils-plants-atmosphere continuum. We will first begin by introducing students to the fundamental principle of the following key physical processes in soils: water retention in soil, water potential (freedom) in soils, the flow of water within soils, infiltration, evaporation, transpiration, root water uptake, and solute transport within soils. Then we will continue by focusing on the feedback between soil and plants and soil and microorganisms. Students will learn how biota's life (plants and microorganisms) may impact soil's physical properties and how the physical properties of soil may impact the emergence of life in soils.

2) Seminar on New emerging topics in Soil Biophysics: This seminar aims to discuss the fundamental biophysical and biochemical processes taking place across the soil-root interface and their emerging impacts on water, nutrient, and carbon flux across the soil-plant-atmosphere continuum. Students will be briefly introduced to some selected state-of-the-art topics and will be asked to perform a deep literature review and present their findings in the form of an oral presentation and an extended summary at the end of the semester.

Media:

Reading List:
Responsible for Module:
Zare, Mohsen, Prof. Dr. mohsen.zare@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
New emerging topics in Soil Biophysics (Seminar, 2 SWS)
Zare M

Soil Biophysics (Vorlesung, 2 SWS)
Zare M

For further information in this module, please click campus.tum.de or here.
Module Description

POL40100: Introduction to Politics & Technology | Introduction to Politics & Technology

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
For this module, evaluations will be based on an exercise in which students will demonstrate that they have gained insights into the major questions that drive the study of politics and research methods and theories which are used to address those questions.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
The module is intended as an introduction to the questions and research being addressed in the main thematic areas of the master's program: big transformations and their environmental, technological, and social dimensions; democracy in a digital age; and global governance, ethics and technology. The links between these areas and research areas found in the TUM, such as economics and policy, digital technologies, social responsibility and corporate governance, and urbanization, mobility, and energy will be explained.

Intended Learning Outcomes:
After participating in the module, students will have a strong overview of the kinds of research questions being addressed by faculty in the HfP. They will be knowledgeable about some of the big questions driving the study of politics and research methods and theories which are used to address those questions: What role does the state play in technological innovation? How well do different political systems address major challenges like climate change, biodiversity loss, and ocean acidification? How is support for democracy impacted by growing economic inequalities? How might new technologies alter forms of societal participation in governance processes?
Teaching and Learning Methods:
The module is offered in the form of two seminars, each dealing with different, but complementary thematic areas. One will focus on big questions for politics in a world of rapidly changing technologies, globalization, migration, and challenges to democracy. The other will look at major policy problems (the Energiewende, Resource depletion, urbanization) and how they are being addressed by governments, industrial actors, and civil society.

Media:
Online-Reader, PowerPoint

Reading List:
A reader of seminar texts with up-to-date and cutting edge scientific literature will be made available at the start of the semester.

Responsible for Module:
Schreurs, Miranda; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
(POL40100) Introduction to Politics, Technology & Sustainability (Vorlesung, 4 SWS)
Jedd T ( Schmid H )
For further information in this module, please click campus.tum.de or here.
Module Description

WI001255: Lecture Series Renewable Energy Systems in the Global South | Ringvorlesung Erneuerbare Energiesysteme im Globalen Süden

Version of module description: Gültig ab summerterm 2020

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>135</td>
<td>45</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Written exam of 60 minutes:
- In multiple-choice questions and short questions, it is examined if the students are able to name and explain facts regarding renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South correctly.
- In computational tasks, it is examined if the students are able to classify relevant location parameters correctly and perform calculations on renewable energy technologies correctly in order to design decentralized energy systems in the Global South according to the framework conditions of a certain location.
- In text tasks, it is examined if the students are able to classify and evaluate technological, economic and social factors influencing renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South correctly.
- The exam is graded.
- Up to 20% of the exam can be multiple-choice questions.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
- Bachelor degree in an engineering study program or a study program, which included technological/engineering aspects (such as B.Sc. Management & Technology)
- Interest in various renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South
- Interest in the socio-economic factors influencing the utilization of renewable energies in the Global South
Content:
Overview of renewable energy technologies including their functionality, their technological and economical assessment, their integration in decentralized energy systems as well as business concepts for their utilization in the Global South:
- Renewable energy systems in the Global South - Why and how?
- Small-scale solar thermals and photovoltaics
- Small-scale hydro-power
- Small-scale wind-power
- Small-scale biogas systems
- Battery storages
- Electrical components of mini-grids
- Rural electrification planning through Geo Information Systems
- System sizing through least-cost modelling
- Sustainable energies and entrepreneurship in the Global South
- Sustainable enterprises for Renewable Energies in the Global South
- Rural electrification projects in the Global South

Intended Learning Outcomes:
After successfully completing the module, students are able to
- Name and explain facts regarding renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South.
- Perform calculations regarding renewable energy technologies in order to be able to design decentralized energy systems in the Global South.
- Classify and evaluate technological, economic and social factors influencing renewable energy technologies, decentralized energy systems and their utilization and operation in the Global South.
- Develop concepts for decentralized energy systems in the Global South based on the technological, economic and social framework conditions of a certain location.

Teaching and Learning Methods:
Lectures and presentations by various researchers from TUM as well as entrepreneurs and other experts from the field of Renewable Energies in the Global South.
In exercise lessons, the taught knowledge of the lectures are applied to exemplary topics. After each lecture, the students conduct these exercises in homework and afterwards, these are discussed during the upcoming exercise lesson. Most of these exercises are calculating tasks about the technical components, but there are also some exercises regarding the financial assessment of renewable energy technologies. The exercises are not graded.

Media:
The following media types are used:
- Computer-aided presentations for the lectures
- Exercises
- Discussion of provided literature
**Reading List:**
- Presentation slides of the speakers
- Solutions of exercise lessons
- Other literature recommended by the speakers

**Responsible for Module:**
Belz, Frank-Martin; Prof. Dr. oec.

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description

WZ1674: Research Methods and Economic Research Project

Version of module description: Gültig ab summerterm 2015

Module Level: Master
Language: English
Duration: one semester
Frequency: winter/summer semester

Credits:* 6
Total Hours: 180
Self-study Hours: 120
Contact Hours: 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Examination Duration (in min.): 30.
The course grade consists of two parts: 50% project report and 50% in-class grade. The in-class grade consists of equal parts each, proposal presentation, project results presentation, peer review of another student's proposal, peer review of another student's project results, and discussion of applications of economic concepts.
Justification: Students demonstrate their ability to apply economic concepts through class discussions and development of project ideas.
Students demonstrate their ability to develop an economics research projects through the stages of proposal presentation, result presentation, and project report.
Students demonstrate their ability to evaluate other researchers’ proposals and results in a constructive manner through presentations of reviews.
Students demonstrate their ability to manage resources, and deadlines through timely submission of the enumerated tasks in stages throughout their research projects.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
BSc. Degree. Prior knowledge of basic ideas of economics and management recommended.

Content:
The module provides master level students with an advanced understanding of the research process, its quality criteria, and the application of economic concepts to questions of food and agriculture. Key economic ideas are applied to everyday questions in class discussions based on economic texts, podcasts, and others. The development, execution, publication, and review of
disciplinary and interdisciplinary research is explained in lectures and carried out by each student from beginning to end. Steps include developing project ideas and research questions; using peer-reviewed literature to frame a student project; designing research plans with the appropriate methods and suitable techniques of data collection; structuring, preparing, presenting, and critically reviewing research proposals; data collection, data analysis, and data presentation; discussion and conclusions based on reflecting own empirical research in the light of the literature; disciplinary, professional, and ethical quality criteria of research in economics and management

**Intended Learning Outcomes:**
Students are able to apply economic ideas to questions related to food and agriculture in everyday life.
Students are able to develop and execute an economic research project in the field of agriculture, horticulture, and food.
Specifically, students are able to develop a project idea, develop a research question and objectives based on the project idea and the related scientific literature, and create a research plan, including the suitable combination of research methods and techniques; defend a research proposal based on the research plan.
Students are able to evaluate other (student) researchers’ proposals and present such evaluations in a suitable form, orally.
Furthermore, students are able to apply their research plan through data collection, data analysis, and presentation of research results, in oral and written form; and are able to evaluate other (student) researchers’ research process, results, and conclusions.
Students are able to manage resources and deadlines.

**Teaching and Learning Methods:**
Lectures, class discussions, and guided student project development and project evaluation (project proposal, proposal review, project results, results review, and research report).

**Media:**
Presentation slides, websites, articles and short texts, multi-media (podcasts, video clips), student presentations, and reviews.

**Reading List:**

**Responsible for Module:**
Vera Bitsch bitsch@tum.de
Courses (Type of course, Weekly hours per semester), Instructor:
Seminar
Research Methods and Economics Research Project
4 SWS
Vera Bitsch
TUM
bitsch@tum.de
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2720: Renewable Energy Technologies | Renewable Energy Technologies

Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a written test, where the students have to proof that they understand and remember the basic technical principles related to energy production and the working principles of the presented renewable energy technologies, as well as the related ecological and economical properties and frame conditions. The students have to answer questions, but may also be asked to do calculations, complete figures or prepare sketches.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
General understanding of natural science, mathematics and basics of technology.

Content:
The course provides an overview of the basics of thermodynamics and the principles of energy conversion. Energy conversion and its importance for the economy is discussed. Because of their transitional character due to the German “Energiewende”, the course focusses on the European and German energy systems. The international students in the course are expected to support the lecture with their experiences from abroad.

Basic technical principles of energy production, efficiencies, costs and environmental impacts will be understood. The focus lies on the following areas: solar, wind, water and geothermal energy conversion.

The course provides an overview of the basics of thermodynamics and the principles of energy conversion. Energy conversion and its importance for the economy is discussed. Because of their transitional character due to the German “Energiewende”, the course focusses on the European and German energy systems. The international students in the course are expected to support the lecture with their experiences from abroad.
Basic technical principles of energy production, efficiencies, costs and environmental impacts will be understood. The focus lies on the following areas: solar, wind, water and geothermal energy conversion.
In order to complete the picture, also storage and fossil fuel technologies will be discussed. The students will understand their role and their contribution to balancing energy production and demand.

**Intended Learning Outcomes:**
At the end of the course, the students understand the technical principles of renewable energy conversion systems.
They are able to interpret energy scenarios and solve simple problems associated with a high renewable energy share and its implications on society.
The students can estimate the importance of distinct technologies for a sustainable energy supply.

**Teaching and Learning Methods:**
Lecture with integrated exercises and teamwork, as well as discussions to improve understanding.

**Media:**
Power point presentation, black board, Videoclips

**Reading List:**
Tba

**Responsible for Module:**
Dr. Doris Schieder - Lehrstuhl für Chemie Biogener Rohstoffe doris.schieder@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Renewable Energy Technologies
Christoph Wieland, Doris Schieder, Annelies Vandersickel
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2737: Remote Sensing and Image Processing | Remote Sensing and Image Processing

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Achievements will be assessed by exercises, a presentation and a final report (project work). On behalf of home exercises the students get a first insight into concepts of image analysis. “Hands on” exercises with state of the art software packages are employed to train the main image processing steps and to assess the understanding of the students in implementing the basic concepts of remote sensing from data take to data analysis. Regular discussions with the tutor measure the student’s ability to develop an idea from initial concepts to the complete picture within a given timeframe, delivering interim results at relevant milestones (35%). On behalf of a presentation of a topic related to remote sensing the student’s ability to understand a technical/scientific subject, to analyze and evaluate facts and factors of influence, to summarize the subject and present it to an audience, and to conduct a discussion about the presented subject is assessed. With the final report the students demonstrate that they have gained deeper knowledge of the specific image analysis software packages and its components, of differing analysis concepts and that they are prepared to evaluate an existing situation as imaged by the respective remote sensing data set. They demonstrate further that they are able to create new geodata layers appropriated to be analyzed in an integrating GIS environment (65%). The grade weights of module examination components correspond to the weighting factors given in brackets.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Module "Inventory Methods and GIS" of the 1th semester of the Master Program "Sustainable Resource Management" passed, computer skills at least at working level.
Content:

Intended Learning Outcomes:
At the end of the Remote Sensing and Image Processing module (RSIP) the students are able to: - decide which data set is most appropriated to solve his thematic task, - access data bases, download and open a data set for image processing, - geocode/georeference digital data sets, - develop appropriated interpretation keys fitting the data set and the targeted thematic goal,- visualize and enhance the data set for interpretation, - extract spectral signatures, - calculate indices on behalf of the data, - learn how to extract bio-geo-chemo-physical parameter from the data set, - perform unsupervised and supervised classifications, - proof the quality of the results by an accuracy assessment, - perform a change detection study, - export the results as GIS layer.

Teaching and Learning Methods:
By using advanced image processing software packages the theoretical explained concepts are exercised “hands on” and discussed on basis of different data types applying the “just in time teaching (JiTT)” technique; the practical courses are prepared by homework (presentation of specific related topics, exercises); the short presentations will be given during the courses, contents, layout and style discussed and narrated; the home exercises explained in close relation to the computer exercises just done. The definition of the problem to be solved by image analysis techniques and the development of appropriated solutions needs research of reference materials. The final outcome of the courses, the classification result, will be used as basis for the Module “Application Study” of the concentration field “Landscape Management”.

Media:
Image processing software and tutorials, prepared exercises, different data types

Reading List:

**Responsible for Module:**
Dr. Thomas Schneider – Fachgebiet für Waldinventur und nachhaltige Nutzung
tomi.schneider@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Remote Sensing and Image Processing (Vorlesung, 6 SWS)
Mengesha M

For further information in this module, please click campus.tum.de or here.
Module Description

WI001165: Sustainable Entrepreneurship - Getting Started | Sustainable Entrepreneurship - Getting Started

Version of module description: Gültig ab summerterm 2017

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module assessment consists of project work. Students are divided into teams of 3 to 5 students. Starting from the student's initial idea, each team has to develop a sustainable business model over the term. By working in a team, students demonstrate their ability to manage resources and deadlines together and to be able to complete their tasks in a team environment.

Each team will work on assigned tasks. Each group member has to contribute to the final group presentation (a 15 minutes pitch per team, 25%) that will take place during the last session of the term. By presenting their sustainable business plan, students demonstrate they are capable of presenting their business model in a clear and comprehensible manner to an audience. In addition, each team member will work on a section of the final written project report, describing and analyzing the sustainable business plan of the team. The written paper is due four weeks after the oral presentation (max. 8,000 words, 75%). By writing the project report students demonstrate that they are able to elaborate more in-depth on their sustainable venture. They also show their ability to apply the theory and real-life examples provided to them to their own idea and business model.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Modules in entrepreneurship, corporate sustainability and/or sustainability marketing are recommended.

Content:
Whether it is tackling climate change, resource degradation or social inequalities - responding to sustainability issues constitutes the biggest challenge for businesses in the 21st century. Embracing a great range of industries including food, energy or textiles, the field of life sciences is a key area for sustainability. Since the production of these goods accounts for an extensive
use of resources, there is great potential for effecting real improvements on a way towards more sustainable production and lifestyles. In this module we want to invite and inspire students to make a difference. We introduce them to the theory and practice of sustainable entrepreneurship, pursuing the triple bottom line of economic, ecological and social goals. We present the sustainable business model canvas as a tool for the students to explore their own ideas and to develop a sustainable business in the area of life sciences. Adopting a step-by-step approach, the following topic will be covered (all topics will be explained in general and then discussed in the context of life sciences):

1) The nexus of entrepreneurship and sustainable development
2) An overview of the theory and practice of sustainable entrepreneurship
3) Social and ecological problems as opportunities for sustainable entrepreneurship
4) Developing a sustainable customer value proposition
5) Describing key activities, resources and partners
6) identifying revenues and costs
7) Consolidating all parts in a lean and feasible business model
8) Pitching and presenting a business model

**Intended Learning Outcomes:**
Upon successful completion of this module, students will be able to (1) discuss and (2) evaluate the socio-economic challenges of the 21st century. They will be able to (3) evaluate the concept of sustainable entrepreneurship as a means for addressing these complex sustainability issues. More specifically, students will be able to (4) perceive socio-ecological problems as opportunities for sustainable entrepreneurship and to (5) generate their own ideas for a sustainable venture. In addition, participants will be able to (6) transfer the provided theory and examples to their own idea and (7) design their own business model. Students will (8) have gained experience and new skills in presenting in front of a large audience. Finally students are able to exchange in a professional and academic manner within a team. They show that they are able to integrate involved persons into the various tasks considering the group situation. Furthermore the students conduct solution processes through their constructive and conceptual acting in a team. They can make this contribution in a time limited environment.

**Teaching and Learning Methods:**
The module is a seminar which intends to familiarize the student with the theory and practice of sustainable entrepreneurship. Since the main goal of the module is to ignite entrepreneurial thinking and passion, as well as to provide the students with the required know-how to get started, the module has an interactive format with excursions and a project work in small groups. A special feature of the module is the co-teaching by an academic and a practitioner with a mutual interest in the theory and practice of sustainable entrepreneurship.

**Media:**
Presentations, slides, cases, links and further literature will be provided via www.moodle.tum.de
**Reading List:**
The module is based on a few key scientific papers and practical tools such as the business model canvas. These form the basis for classroom discussions and are to be used for developing an own business model. All materials are provided as pdf files in TUM Moodle (https://www.moodle.tum.de).
Students should be familiar with the United Nations’ Sustainable Development Goals (SDGs) and the basics of the business model canvas:
Business Model Canvas:

**Responsible for Module:**
Belz, Frank-Martin; Prof. Dr. oec.

**Courses (Type of course, Weekly hours per semester), Instructor:**
For further information in this module, please click campus.tum.de or here.
Module Description


Version of module description: Gültig ab summerterm 2019

<table>
<thead>
<tr>
<th>Module Level: Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
<th>Frequency: summer semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits:* 5</td>
<td>Total Hours: 150</td>
<td>Self-study Hours: 90</td>
<td>Contact Hours: 60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment type for the module is a graded report (10 pages). The report includes three sections: (1) critical analysis of a published empirical sustainability study in the context of its sustainability definitions and authors’ backgrounds; (2) critical analysis of a sustainability measurement system in use with regard to fulfilling requirements to be met by indicators and indicator systems; (3) critical analysis of a public sustainability claim by an organization from a consumer or citizen point of view. Each analysis is also presented by each student. Through reports, the students demonstrate the ability to understand relevant research, measurement systems and claims, as well as critically analyze and discuss these issues. Through the presentation and discussion of each analysis, students demonstrate their ability to communicate these critical issues and further reflect on each topic in the light of other students’ questions and presentations.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge and understanding of economic and management concepts as well as of social science research methods is required.

Content:
The development of a differentiated understanding of sustainability requires the critical analysis and reflection of sustainability concepts on multiple levels. In the module the following levels are systematically analyzed and discussed based on guided discussions of assigned readings and materials developed by students based on literature and internet research:
- Paradigms and value judgments in research on and evaluation of sustainability;
- Economic, environmental and social aspects of sustainable production, marketing, and consumption;
- Measurement systems for sustainability on different levels (products, supply chains etc.);
- Public and private standards, sustainability certifications and communication;
- Consequences of measurement systems and their foci, e.g., on environmental aspects, such as carbon footprint, or on social aspects, such as fair trade.

These topics are discussed in the context to current and controversial issues regarding sustainability in science and in society.

**Intended Learning Outcomes:**

After successfully completing the module students are able to
- Analyze and evaluate the consequences of different paradigms on the definition and understanding of sustainability and its use in published scientific articles;
- Analyze and evaluate sustainability measurement systems on the product, enterprise, and supply chain levels as well as their potential consequences;
- Evaluate public sustainability claims based on the research of available information sources;
- Apply a differentiated understanding of sustainability in an interrelated, globalized context with differing value systems and priorities in scientific and practical questions and issues.

**Teaching and Learning Methods:**

The course “Sustainability: Paradigms, Indicators, and Measurement Systems” has a seminar format based on assigned readings and student presentations on assigned topic areas.

After an introductory guided class discussion on assumptions and implicit sustainability definitions of participants, readings are assigned and discussed in class to lay the basis for later student presentations. Through individual document research and individually prepared class presentations, students develop the ability to critically reflect on sustainability research, sustainability indicators and measurement systems, as well as sustainability claims by various actors and organizations. Through presentations and concept discussions, students develop in-depth knowledge of sustainability issues and hone their critical thinking skills. A final discussion summaries students’ learning and additional findings throughout the semester in the concept of wicked problems.

**Media:**

Reading assignments; use of data bases for literature research; presentation software; discussion facilitation support media, such as flipcharts and discussion boards; video clips and podcasts.

**Reading List:**


Current articles on sustainability paradigms, requirements of sustainability indicators and indicator systems, and applications.

**Responsible for Module:**
Courses (Type of course, Weekly hours per semester), Instructor:
Sustainability: Paradigms, Indicators, and Measurement Systems (Seminar, 4 SWS)
Bitsch V [L], Bitsch V, Carlson L
For further information in this module, please click campus.tum.de or here.
Module Description

WZ1921: Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry

Version of module description: Gültig ab winterterm 2019/20

Module Level: Master
Language: English
Duration: one semester
Frequency: winter semester

Credits:* 6
Total Hours: 180
Self-study Hours: 120
Contact Hours: 60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment type for the module is a graded learning portfolio (100%). The portfolio includes memorandums addressing 9-10 of the case studies discussed in class; and a learning statement addressing conceptual, scientific and personal learning. Through the case memorandums, the students show the ability to discuss the assigned case questions by selecting and applying suitable theoretical concepts to supply chain management and sustainability challenges in the specific context of agribusiness and the food industry. In the learning statement, students demonstrate the ability to reflect on the semester long learning process and summarize the insights gained.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Solid economic and management background; knowledge of basic concepts of strategic analysis, planning, and management (e.g., industry analysis, horizontal and vertical coordination, and SWOT), as well as the ability to apply these concepts; furthermore, knowledge of value chain management is required (e.g., theoretical background, supply chain dynamics, actors and partnerships, governance). Successful completion of a management course on M.Sc. level required, e.g., agribusiness management or value chain management. Medium level experience in desk research and scientific writing is required.

Content:
The module builds on key concepts of supply chain management, strategy, and sustainability to provide master level students with the competency to evaluate pertinent issues in agribusiness and food industry supply chains.
Topics covered include:
- value propositions, creating and capturing added value in agribusiness and the food industry
- management of customers, suppliers, and other stakeholders
- innovation in supply chains, sustainability as an innovation, sustainable supply chains
- CSR (corporate social responsibility) and sustainability measurement
- implementation of a sustainability strategy, as well as costs and benefits of sustainable practices in agribusiness and the food industry
- ethical issues in supply chain management.

Intended Learning Outcomes:
After successfully completing of the module, students are able to evaluate processes of supply chains management in agribusiness and the food industry. Specifically, students are able to
- evaluate value propositions, as well as plans for creating and capturing value
- evaluate the management of customers, suppliers, and other stakeholders
- independently choose scientific models or concepts relevant to the analysis process of agricultural and food industry supply chains and justify their choice
- evaluate the implementation of a CSR concept or sustainability strategy, and monitor its effects on operations, suppliers, associates, and customers
- identify and analyze ethical issues in supply chain management and to recommend how to apply ethical practices.

Teaching and Learning Methods:
The course Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry has a seminar format based on the case study method. The seminar format is implemented based on case descriptions of problems, challenges, and innovations in agribusiness and food industry supply chains. Through individually prepared class discussions and group work, students develop the ability to critically reflect and apply concepts of strategy, supply and value chain management, and sustainability requirements in the context of agribusiness and the food industry. During class discussions and group presentations, students reflect on their experiences, prior knowledge, and assignments to develop an in-depth understanding of current challenges in supply chains and how to address the.

Media:
Reading assignments; case descriptions; presentation software; discussion facilitation support media, such as flipcharts and discussion boards; video clips and podcasts.

Reading List:
Current articles from scientific journals as appropriate.
Selected chapters from
Pullmann and Wu (2011): Food Supply Chain Management: Economic, Social and Environmental Perspectives. Routledge, New York, US.
Responsible for Module:
Bitsch, Vera; Prof. Dr. Dr. h.c.

Courses (Type of course, Weekly hours per semester), Instructor:
Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry (Seminar, 4 SWS)
Bitsch V [L], Köksal S, Huhn C, Carlson L
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2734: Soil Protection | Soil Protection

Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In an oral exam of 30 minutes duration, students demonstrate in a scientific discussion by answering questions without helping material their broad and deep understanding on how to protect soils. The understanding of soils, as achieved in the modules "Introduction to soil science" and "World soil resources", is implicitly part of the oral exam.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
The successful completion of the module "Introduction to Soil Science" or equivalent skills are required. The successful completion of the module "World Soil Resources" is recommended.

Content:
Principles of soil degradation, the world food problem, highly erodible soils, semi-arid environments (including irrigation and salinization problems), kaolinitic soils, shifting cultivation, organic and mineral fertilization, agroforestry, land use and greenhouse gases, soil functions, organic pollutants, inorganic pollutants (heavy metals), radionuclides, pesticides, pathways of pollutants, sorption, precipitation, co-precipitation, acidification, ways to assess the mobility of pollutants, remediation of brownfields.

Intended Learning Outcomes:
The students are able to apply their knowledge of soils, as achieved in the modules “Introduction to Soil Science” and “World Soil Resources”, to develop strategies of soil protection. They understand the major environmental factors that determine the food production in the world. They are able to address the specific problems of highly erodible soils, semi-arid land and kaolinitic soils and to design adequate land-use methods. The students understand the major factors that determine the fate of substances in soil. They are able to analyze and forecast the fate of heavy metals, organic
pollutants and radionuclides in soil and are familiar with important techniques for managing and remediating brownfields.

Teaching and Learning Methods:
Lecture, discussions

Media:
Presentation notes.

Reading List:

Responsible for Module:
Schad, Peter; Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:
Bodenschutz - Organische und anorganische Schadstoffe in Böden (Vorlesung, 2 SWS)
Bucka F

Soil Protection and World Food Production (Vorlesung, 2 SWS)
Schad P

For further information in this module, please click campus.tum.de or here.
Module Description

BGU70005: Transportation Economics | Transportökonomie
[Transportation Economics]

Version of module description: Gültig ab winterterm 2017/18

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination type of the module is a project work.
In the project work, a realistic task from the area of the economic evaluation of transport systems (e.g., congestion charge, infrastructure investments, sharing concepts) is used to check whether the students are able to evaluate the suitability of the different assessment methods presented in the lecture and choose a suitable one for their project. They also show that they can apply the selected methods correctly to the concrete example, quantify them, and use the results to assess the feasibility and the impact of the project. The participants will do midterm and final presentations, and finally submit a written project work. The final grade will be determined as follows: midterm presentation: 15%, final presentation: 35%, written project work: 50%

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
--

Content:
The module provides the students with an overview of the tools and methods that are available to evaluate transportation systems from an economic point of view. The following key areas will be covered:
• Introduction to Transport Economics
• Demand and Supply
• Equilibrium
• External Interactions
• Projects appraisal
• Transportation Investments
Intended Learning Outcomes:
After completion of the module, the students will understand the methodological basis for the economic evaluation of transport systems and infrastructure investments. They are able to evaluate the main economic aspects from the field of transportation systems, transportation measures and investments. Additionally, the students are able to apply core theories of transport economy, such as external cost, marginal social cost, cost/ benefit considerations, demand/ supply interactions and elasticities to practical tasks, evaluate projects and use their calculation results for feasibility recommendations.

Teaching and Learning Methods:
Format: Lecture with integrated practical exercises;
Lectures provide the students with the theoretical basics of the economical assessment of transportation systems and projects, e.g. the various building parts of the models, their boundary conditions and application fields, as a Powerpoint presentation, supported by pictures, possibly films and discussions. Practical calculation tasks from realistic studies and models as well as the supervision of a project work provide the quantitative methods for application and calculation of the methods as well as the interpretation of the model results for their use in feasibility and economic impact considerations for projects.

Reading List:

Media:
Presentation slides, whiteboard, readings

Courses (Type of course, Weekly hours per semester), Instructor:
Transportation Economics (Vorlesung mit integrierten Übungen, 4 SWS)
Antoniou C [L], Abouelela M, Antoniou C, Lu Q, Moghavem Ghaffari S
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2936: Sustainable and Environmental Regulations | Sustainable and Environmental Regulations

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Successful completion of the course will be based in both seminars on the quality of the presentation in the seminar and a written executive summary on the topic of the presentation (course 1: presentation of around 30 min; executive summary of 5 pages; course 2: presentation of around 30 min; executive summary of around 3 pages).

The presentation is a means to measure the students’ ability to understand the context and complexity of sustainable development in different countries and formal impact assessment procedures by preparing and delivering a well-researched and instructive oral presentation on a certain facet. An accompanying executive summary of major findings and conclusions indicates the capacity of the students to summarise the presentation in a clear and concise manner. In addition, the students are expected to show their oral communication skills by responding competently to questions and comments by the audience as well as by contributing to class discussions. Depending on the number of seminar participants, the presentation may be given either individually or in groups.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Class discussion is a core element of the seminars. Therefore, students are expected to take part and contribute to the discussions. Recommended Prerequisites: Module WZ2713 Methods of Scientific Communication.

Content:
Course 1 "Sustainable Development and Regime Type": The seminar introduces both the theoretical debate on sustainable development and the discussion about the role political regime type (democracy, autocracy, hybrid regime) play for the sustainability performance of a country.
What are the goals of "sustainable development"? Which policy areas have a strong relationship to sustainability? To what extent do countries differ in their "sustainability profile" in various policy areas? What influence does the regime type play in this regard?

The seminar investigates these theoretical and empirical issues in the context of pressing future challenges, such as rising government debt in many countries, growing global competition for innovation, and intensifying global environmental degradation and resource scarcity. The seminar will focus on discussing theoretical approaches to current "sustainability debates" and considering what defines generationally just behavior. In addition, empirically based comparisons of countries under different political leadership will be made looking at several sustainability areas (e.g. economic, financial, educational, research, family, pension, environmental and energy policy).

Course 2 "Methods of Environmental Assessment": The seminar introduces the methodology of EIA and SEA as worldwide established instruments for assisting sound environmental management. Being integral parts of spatial planning and decision-making, the assessment procedures integrate biophysical and socioeconomic information to predict and evaluate the environmental consequences of proposed projects, plans and policies and to suggest means to avoid or mitigate significant impacts. The seminar gives an overview of the concepts, methods, procedural elements of EIA and SEA and stimulates discussion on key aspects of environmental assessment.

**Intended Learning Outcomes:**
At the conclusion of the module, the students will have basic knowledge on sustainable development, its theoretical and empirical implications and its most important policy fields. The students understand the structure and the functioning of different political regimes and are able to evaluate their impact on the sustainable development of a country. Furthermore, the students are able to appreciate the purpose of EIA and SEA and their role in the decision-making process; explain the major principles and procedural steps of EIA and SEA; know options for estimating environmental impacts; reflect critically on the strength and limitations of the instruments; communicate findings in class and comment on the work of fellow students.

**Teaching and Learning Methods:**
In the SDRT seminar lectures, presentations and discussions provide students with a basic knowledge on sustainable development and political regime type and allows them to evaluate the performance of different states with regard to their sustainability performance.

In the MEA seminar, presentations by students and the lecturers provide the basis for exploring and discussing the concepts, methodology, current practice and potentials of environmental assessment. Class discussions engage students in critical thinking and analysing the scope and limitations of the presented material.
Media:
The module includes lectures, presentations, class discussions, (small group) exercises and assigned readings.

Reading List:

Responsible for Module:
Augenstein, Isabel; Dr. agr.

Courses (Type of course, Weekly hours per semester), Instructor:
Methods of Environmental Assessment (Seminar, 2 SWS)
Augenstein I

(WZ2936) Sustainable Development and Regime Type (Seminar, 2 SWS)
Wurster S ( Mohammed N, Schmid H )
For further information in this module, please click campus.tum.de or here.
Module Description


Version of module description: Gültig ab summerterm 2021

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The proof of performance will be made in the form of a project. This project will be conducted in small groups of 6-8 students, whereby an individual thematic focus will be defined for each student. It consists of a group report (70%, 3-5 pages per student) and interim and final presentations (30%, ca. 5 min per student) where individual contributions will counts for 60% and group interaction for 40% of the grade. The aim of the project is to prove understanding of basics of different technical and non-technical components of integrated urban planning and their application in the development of simple urban planning projects. The project requires an intensive analysis of the thematic focus and thus the students prove an in-depth understanding of these components and the ability to combine these in an innovative way. This understanding will be proven using planning, geographic information systems-based, calculatory and modeling methods. At the end of the course, the students prove their ability to present and explain their concepts, approaches and methods in front of an expert audience through a presentation and a short discussion. Further, students proves their ability to work scientifically on their individual content through submission of the individual parts of the report.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Water and Wastewater Treatment Engineering (BGU38014)

Content:
This module deals with concepts, approaches and methods for integrated urban planning. Good practice examples are discussed in general terms before learning to apply these to a concrete case study city. In addition, students will learn about concepts and driving forces of the topics urbanization, globalization, climate change, environmental challenges, sustainability including UN
Sustainable Development Goals (SDGs) as well as current research on water reclamation with resource recovery.

**Intended Learning Outcomes:**
Upon successful completion of this module, students are able
- To know and explain contextual challenges and existing concepts, approaches and methods to address these
- To understand and explain international development dynamics and implications for natural resources consumption patterns
- To choose and compare technical and non-technical components of integrated urban planning
- To evaluate technical and non-technical components of integrated urban planning in terms of their context
- To develop innovative concepts and combinations of these components
- To communicate in an interdisciplinary group and collaborate on joint results
- To present own results in a scientific manner in presentations and a report

**Teaching and Learning Methods:**
The module will be taught as a combination of a lecture series and a project. Major content will be explained in form of lectures with integrated discussion. In the project, students will work with the guidance of the tutor to develop solutions for selected case studies. Following an introduction into the project, they will work in groups, where every student will work on individual aspects of the project. Results will be presented in a joint group report and a final presentation.

**Media:**
Presentations, group work

**Reading List:**

**Responsible for Module:**
Keilmann-Gondhalekar, Daphne (d.gondhalekar@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click campus.tum.de or here.
Module Description

WZ0528: Urban Forestry | Urban Forestry

Version of module description: Gültig ab winterterm 2018/19

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>60</td>
<td>90</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module is assessed by a written test, where students are required to demonstrate knowledge of theory and methods of urban forestry as well as of the project seminar without additional aids. Questions are briefly answered in student's own wording and include the solving of computational tasks that employ allometric relationships of tree growth and ecosystem services. Duration (min): 90. An additional study project on the growth and ecosystem services or urban trees offers the opportunity to obtain 6 cp in total.

Repeat Examination:

(Recommended) Prerequisites:

Content:
Urban forests are defined as the entire stock of trees in urban and peri-urban areas. Urban forestry is an approach for their multifunctional planning, design and management to provide multiple aesthetic, ecological, social, and economic benefits for the people living in cities. The module aims to provide participants with advanced knowledge and skills for this purpose. The module consists of lectures and a study project. Lectures cover the following topics:
- Urban forestry concepts and tasks
- Urban forest design
- Multifunctional urban forest management
- Ecophysiology of urban trees
- Tree growth and structure
- Moderating urban climates by urban forests and trees
- Phenology of urban trees
- Modelling ecosystem services of urban forests and trees
• Species selection for urban plantings

Participants will undertake a study on urban tree growth which provides them with an opportunity to obtain in-depth knowledge on growth patterns of different species and their ecosystem services in relation to environmental conditions in urban areas.

**Intended Learning Outcomes:**
On successful completion of the module, participants are able to (i) understand concepts of urban forestry and how these are applied in practice, (ii) analyse the climatic functions of the urban forest, (iii) apply methods for analysing urban forests, (iv) analyse and evaluate ecosystem services of urban forests, and (v) apply this knowledge and the methods in a study project. In the study project, students shall demonstrate their ability to independently apply a methodology for the measurement and analysis of important parameters of urban tree growth, in order to derive ecosystem services of the trees (e.g. carbon sequestration, shading) and to draw conclusions for the management of urban trees.

**Teaching and Learning Methods:**

**Media:**

**Reading List:**

**Responsible for Module:**
Stephan Pauleit, Thomas Rötzer

**Courses (Type of course, Weekly hours per semester), Instructor:**
Urban Forestry (Vorlesung mit integrierter Übung) (Vorlesung, 4 SWS)
Lupp G, Pauleit S, Pretzsch H, Rahman M, Reischl A, Rötzer T, Torano Caicoya A

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://campus.tum.de).
Module Description

WZ1344: Urban Agriculture | Urban Agriculture

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module grade is based on a written report (approx. 20 pages; 80% of grade) complemented by a group oral presentation (15 min. + 5 min. discussion; 20% of grade). In the report, the students design a strategy for ecologically-oriented sustainable urban agriculture. Here, students should situate their strategy in a theoretical framework, and evaluate the relevant ecological and social context of their strategy. Written summaries measure the student’s understanding and evaluation of ecological and social aspects, and ability to apply theoretical frameworks. In the presentation, the students collectively present their strategy (PowerPoint plus any additional aides) to demonstrate understanding of an urban agriculture system, communicative competence, presentation and discussion skills in front of an audience.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
Basic knowledge in ecology, agriculture, landscape ecology is an advantage

Content:
Urban agriculture has experienced a renaissance in recent decades. What are the possibilities for sustainable urban agriculture that supports multiple ecosystem services? This module explores ways in which urban agriculture can aid in the enhancement of food security, biodiversity, energy conservation, public health and well-being in cities. We will discuss the agro-ecological basis of urban horticultural production systems adapted for city environments. Topics include fundamentals of horticulture, soil properties and fertility, pest and pollinator management, animal agriculture, and climate change impacts. The students will learn about methods of urban agriculture and innovative approaches to ecologically-oriented and climate-resilient urban agriculture. In addition, they will study how urban food production interacts with social, cultural, and political dimensions.
of urban environments (e.g. city policy, economics, human health) to foster an interdisciplinary understanding.

**Intended Learning Outcomes:**
On successful completion of the module, participants are able to:
1. understand important ecological aspects of urban agriculture such as biodiversity, soil management and climate mitigation;
2. relate social aspects of urban agriculture to ecological aspects such as public health and urban policy;
3. apply ecological theoretical frameworks to urban agricultural systems;
4. evaluate the ecological and social context of urban agriculture;
5. create a strategy for a sustainable urban agricultural system in a project;
6. communicate their strategy with understanding and evidence.

**Teaching and Learning Methods:**
The module is highly interactive and combines lectures with field trips and presentations from guests and peers. The lecture series will cover topics including: fundamentals of horticulture; soil management; pest and pollinator management; urban agriculture and climate change; challenges of urban agriculture; public health; and the business of urban agriculture. The seminars are based in experiential learning. In the seminars, we will 'see' cities as edible: in the present on field trips; in the past through films and advanced readings; and in the future through group presentations that design urban farming systems for future cities.

**Media:**
PowerPoint, films, virtual lectures

**Reading List:**

**Responsible for Module:**
Egerer, Monika; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
HEF Summer School in Agroecology and Urban Agriculture (Vorlesung mit integrierten Übungen, 4 SWS)
Egerer M [L], Burger S, Egerer M, Schmack J
For further information in this module, please click campus.tum.de or here.
**Module Description**

**WZ2723: Utilization and Treatment of Special Materials and Waste | Utilization and Treatment of Special Materials and Waste**

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>120</td>
<td>30</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

**Description of Examination Method:**
The learning outcome will be assessed by presentation (40 minutes per working group; about 10 minutes per person). The presentation will be complemented by a brief written precis. This assessment method is a good means to evaluate both whether the students are able to work self-reliantly on a topic and to present their significant results to an auditorium and whether they have understood their respective selected topic.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in natural science (biology, chemistry, ecology, physics) and engineering.

**Content:**
The students acquire detailed and differentiated knowledge about the following topics:

- Selected materials, products and production processes concerning high waste generation and heavy environmental problems
- Origin and types of the specific wastes,
- Classical disposal,
- Waste as a source of raw material,
- Utilization for products,
- Energetic utilization,
- Legal specification.

The special topics addressed depend on relevance, e.g. food and food waste, sewage sludge, e-waste or the like.
**Intended Learning Outcomes:**
By the means of the module the students are able:

- to describe the differences of special waste, e.g. food waste and selected municipal or industrial waste,
- to classify the amount and quality of special waste streams,
- to analyze problems concerning the special wastes,
- to develop treatment measures to handle the waste for avoiding or reducing impacts on the environment and human health,
- to transmit developed solutions to other waste and new products.

**Teaching and Learning Methods:**
The module consists of a lecture, providing the theoretical foundations, in combination with a seminar including feedback by the lecturers to the students’ work. The students have to define and to solve problems collaboratively in group work by studying specialist literature. At the end they have to prepare a presentation and a brief summary including problem statement and conclusions as homework under time constraint about this topic. The students are supervised by the lecturers.

**Media:**
PowerPoint Presentation

**Reading List:**
Additional literature depending on themes.

**Responsible for Module:**
Weber-Blaschke, Gabriele; Apl. Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Utilization and Treatment of Special Materials and Waste (Seminar, 2 SWS)
Weber-Blaschke G [L], Reh K
For further information in this module, please click [campus.tum.de](https://campus.tum.de) or [here](#).
Module Description

LS10006: Vertical Farming (MSc.) | Vertical Farming (MSc.)

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination performance is given in the form of a project work. It consists of a written report (approx. 15 pages; 60% of the grade), supplemented by two oral group presentations ((i) 60 min., 20% of the grade; (ii) 15 min. + 10 min. discussion, 20% of the grade). In the final written paper, students present their design for a concept for a Vertical Farming Indoor System on the Weihenstephan campus. In it, the students also demonstrate that they can evaluate the aspects of Vertical Farming with regard to your concrete application in the experimental station (Lab) on site. In the presentation (PowerPoint and additional tools), students collectively present an (i) analysis on vertical farming systems, hydroponics, aquaponics and related technologies, and a (ii) strategy to explain the Vertical Farming system, demonstrate their communication skills as well as their presentation and discussion skills in front of an audience.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Basic knowledge in engineering, agriculture and computer sciences is an advantage.

Content:
The module will focus on Vertical Farming, which can contribute to the improvement of sustainable food production, resource management and energy conservation. The fundamentals of Vertical Farming production systems will be discussed and adapted to urban conditions. Concept development and design of Vertical Farming-systems (hydroponics and aquaponics), electrical and artificial intelligence, plant and pest management are the core topics of the module. Students will learn methods and innovative approaches for vertical farming systems, and they will develop the concept for a Vertical Farming indoor system as part of the Sustainable Living Lab initiative. The highly automated system with integrated lighting will serve as a prototype and be able to produce food 365 days a year.
The module will consist of a project (PT) where students have to design a Vertical Farming-system.
The Module is intended to provide a framework for structured discussions around the topic of sustainability and sustainable food systems in urban areas and to offer practical opportunities for implementation. Sustainability will also be considered in the construction and energy supply. Interdisciplinary collaboration between different disciplines is crucial to the successful implementation of the concept.

**Intended Learning Outcomes:**
On successful completion of the module, participants are able to:
1. analyze the benefits and trade-offs of vertical farming systems and their role in sustainable food systems
2. understand the fundamentals of hydroponic and aquaponic systems;
3. create a concept for a Vertical Farming indoor system for the Sustainable Living Lab that integrates electrical engineering, artificial intelligence, and architecture on the Weihenstephan Campus;
4. develop a strategy for plant management and VF system management;
5. communicate their VF concept and design with understanding and evidence.

**Teaching and Learning Methods:**
The module will consist of a Project (PT) where students will design a Vertical Farming system. The Module is an interactive, hands-on, and interdisciplinary teaching format based on experimental learning with a strong emphasis on group work and discussion in a "flipped classroom design". In this respect, it is a project, as students will design their own concept. Guest lectures and basic information on vertical farming systems, pest management, hydroponics, urban agriculture challenges, and public health and awareness will further support students. In addition, students will have the opportunity to attend the Urban Agriculture course lecture series. Participants in groups will have access to the high-tech Makerspace workshop and a start-up budget to develop their own concept. Students from all faculties can participate in the module. The project is offered in English so that international students can also be integrated.

**Media:**
Presentations, scientific articles, group discussions, posters.

**Reading List:**
Not specified

**Responsible for Module:**
Egerer, Monika, Prof. Dr. monika.egerer@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**

For further information in this module, please click campus.tum.de or here.
Module Description

WZ4201: Vegetation Ecology and Geographical Information Systems | Vegetation Ecology and Geographical Information Systems

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
A written exam (Klausur) assesses whether the students understand the basic concepts of spatial data analysis as well as vegetation ecology with respect to manage landscapes, the students’ ability to apply these techniques to certain problems in landscape management as well as the students’ ability to precisely describe solutions to achieve certain results within a limited amount of time.

A voluntary Mid-Term assignment (presentation) assesses the students’ ability to communicate management plans based on vegetation and habitat data. It will serve for grade improvement by 0,3 according to §6 (5) APSO.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in GIS, remote sensing, for example learned by attending the module "Inventory Methods and GIS". Basic knowledge of plant species.

Content:
1. Advanced analysis and visualization of spatial data;
2. GIS based raster analysis;
3. GIS and satellite navigation;
4. Application of GIS in selected projects;
5. Introduction to the vegetation ecology, theory of plant distribution and of plant communities;
6. Methods of habitat mapping;
7. Habitat mapping in the field;
8. Field data analysis;
Intended Learning Outcomes:
At the end of the module students are able to:
- manage, analyze and visualize spatial data to solve problems related to landscape management;
- break down general problems in landscape management to tasks which can be solved by using a GIS;
- develop and communicate management plans based on vegetation and habitat data;
- ascertain and classify habitats.

Teaching and Learning Methods:
Theoretical explanation of certain topics followed by practical exercises using GIS software supported by screen animations.
Transfer of theoretical knowledge in lectures (vegetation ecology, habitat mapping), practical field work and presentation of proposals for landscape management measures.

Media:
GIS Software, PowerPoint Presentation

Reading List:
To be announced

Responsible for Module:
Döllerer, Martin; Dr. rer. silv.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Module Description


Overview of current research topics from local to global

Version of module description: Gültig ab winterterm 2021/22

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>German/English</td>
<td>one semester</td>
<td>winter/summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>105</td>
<td>45</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination consists of a presentation (approx. 20 min.; 25% of the grade) and is supplemented by a written report (report of approx. 10 pages; 75% of the grade). In the presentation, students should demonstrate that they can independently research and professionally present their findings. Through the written report, students should demonstrate that they can communicate specialized knowledge about ecology, conservation, biodiversity, sustainability, and resource use in writing. Students should also demonstrate that they can evaluate current problems and research questions as well as transdisciplinary connections between research, planning, nature conservation and environmental protection, politics and society in this subject area.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Depending on the topic, basic knowledge of landscape- , vegetation- , wildlife- , forest- or soil ecology, as well as climatology and land use is necessary.

Content:
The module consists of a seminar and an exercise.
In the seminar, selected topics on ecology, nature conservation, biodiversity and sustainability research are presented in a series of guest lectures by internationally or nationally renowned scientists.

In the exercise, the results are presented and discussed by students in relation to the other contributions.

**Intended Learning Outcomes:**
Upon successful completion of this module, students will be able to,
- understand sophisticated technical knowledge on diverse topics in the field of ecology, nature conservation and sustainable resource production and use;
- evaluate the quality of presentations by internationally or nationally recognized experts on selected topics in ecology, nature conservation, biodiversity and sustainability research according to methods and techniques, content and form;
- conduct research on the biography and professional focus of researchers, and
- present the results of their analysis and research efficiently and appropriately in a written report and to present and critically discuss them in a presentation.

Students will thus be able to critically evaluate current problems and research questions as well as transdisciplinary connections between research, planning and management, conservation and environmental protection, politics and society.

**Teaching and Learning Methods:**
The students prepare for each lecture by reading the publications of the guest scientists and important related studies in the field. During the lecture, they assess how the subject matter is prepared and presented by the guest scientists. Based on the publications of the scholars and the lecture, the students analyze the methods and techniques used by the scientists to communicate their subject matter. By critically analyzing publications and lectures, students learn how established scientists present and communicate their scientific content to the public. By comparing and discussing several guest lectures as part of the exercise, students learn techniques for communicating specialized knowledge effectively both orally and in writing. The combination of presentations and written reports of students corresponds to the profile of requirements that graduates are often confronted with in the professional fields of ecosystem management, nature conservation, landscape planning and public relations.

**Media:**
Seminar: PowerPoint presentations, script;
Exercise: original scientific articles, students' own presentations.

**Reading List:**
Topic-specific literature for the seminar will be announced.
Responsible for Module:
Leonhardt, Sara Diana; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Seminar Angewandte Ökologie und Planung (Seminar, 2 SWS)
Kollmann J, Häberle K, Annighöfer P, Egerer M, Geist J, Grams T, Schäfer H, Kögel-Knabner I,
Leonhardt S, Menzel A, Pauleit S, Pretzsch H, Rammig A, Rötzer T, Seidl R, Tellier A

Weihenstephaner Kolloquium zur Angewandten Ökologie und Planung (Kolloquium, 2 SWS)
Kollmann J, Häberle K, Geist J, Grams T, Kögel-Knabner I, Leonhardt S, Menzel A, Pauleit S,
Schäfer H, Seidl R, Tellier A

For further information in this module, please click campus.tum.de or here.
Module Description


Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module grade is based on a written exam (90 min.) at the end of the module. The examination measures the student’s ability to assess wildlife monitoring methods on the different fields of its applications and to evaluate the quality and application of monitoring data for management strategies. The learning success will be assessed by covering the knowledge and competence achieved in the main branches “Strategy and Planning”, “Field Monitoring”, “Genetic Monitoring” and “Statistics” in wildlife monitoring. In the written examination students demonstrate their theoretical and practical (e.g. application of methods) knowledge about wildlife monitoring by answering questions under time pressure and without helping material. For answering the questions, the students require their own wording.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
The module combines the theoretical background and the practical implementation of wildlife monitoring methods in ecology. The key aspects are:
1. Introduction and objectives of wildlife monitoring methods; terrestrial, aquatic, and genetic monitoring
2. Strategies and planning of wildlife monitoring
3. Field-monitoring methods of terrestrial and aquatic systems
4. Genetic-monitoring methods
5. Statistics of field-monitoring data
7. Assessment of monitoring data
8. Application of monitoring data for management strategies

**Intended Learning Outcomes:**
After the course students are able to:
- understand the content and objectives of wildlife monitoring,
- design and plan research projects in wildlife biology with the focus on monitoring data acquisition,
- select appropriate field monitoring and genetic monitoring methods,
- understand the statistical principals of ecological and population genetic analyses
- apply R-statistic tools, population genetic software and geoinformatic tools
- interpret processed ecological and genetical parameters
- apply appropriate monitoring methods for specific management questions
- validate applied monitoring methods described in literature

**Teaching and Learning Methods:**
Learning contents will be conveyed during a seminar covering theoretical and applied background information, practical exercises in field monitoring, practical exercises in genetic analyses, practical exercises in statistics (R-package) and practical exercises in GIS (ArcGIS) focused on wildlife monitoring. Group discussions for developing monitoring methods as well as for assessing methods, data and implementation strategies, apply the gained knowledge. The content of the seminar and practical exercises is based on international research projects. Real-world data provide the structure for the course.

**Media:**
lecture notes, flip-chart/board, handouts, real world raw data, software tools

**Reading List:**

**Responsible for Module:**
Prof. Dr. Ralph Kühn - Lehrstuhl für Zoolgie Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising; 08161/71-4608; kuehn@wzw.tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
For further information in this module, please click campus.tum.de or here.
Module Description

WZ2735: World Soil Resources | World Soil Resources
Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level: Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
<th>Frequency: summer semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits:* 5</td>
<td>Total Hours: 150</td>
<td>Self-study Hours: 80</td>
<td>Contact Hours: 70</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In an oral exam of 30 minutes duration, students demonstrate in a scientific discussion by answering questions without helping material their fundamental understanding of the soils of the world in relation to other ecological factors, and they remember the soils of the field course as well as the methods of surveying and classifying soils in the field. In a pass/fail exam (laboratory assignment) in the field of 10 minutes duration, they prove their ability to survey and classify soils of various landscapes and environmental settings. The understanding of soils, as achieved in the module "Introduction to soil science" is implicitly part of the oral exam.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
The successful participation at the module "Introduction to Soil Science" (which is given in the first half of the summer semester) is required.

Content:
• Soils of the world
• Chemical, biological and physical properties of soils
• Genesis of soils as the result of soil-forming processes
• Soil survey
• Soil classification according to the international system
• Soil interpretation.

Intended Learning Outcomes:
The students are able to apply their knowledge of soils, as achieved in the module “Introduction to Soil Science”, to all soils of the world. The students understand the characteristics of the soils of the world, the pattern of their geographical distribution, their genesis, their ecological potential and
the threats to their functions. The students are able to survey a soil profile, to detect the genesis of the surveyed soil and to classify it according to the international soil classification system. They are able to evaluate the possibilities and risks of soil management. They can assess the relationship between the soil and its environmental setting.

**Teaching and Learning Methods:**
The lecture gives an overview of all soils of the world. The field course (several days) presents soils in a landscape outside southern Bavaria. The students are trained in the methodological skills of soil survey, soil classification and soil interpretation.

**Media:**
Lecture: presentation notes. Field Assessment: spade, auger, knife, colour charts.

**Reading List:**
Prepared by Schad, van Huyssteen, Micheli. FAO World Soil Resources Reports 106.

**Responsible for Module:**
Schad, Peter; Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Course 1:
World Soil Resources: Lecture
Course 2:
World Soil Resources: Field Course
Lecturer 1:
Dr. Peter Schad
Lecturer 2:
Dr. Peter Schad
For further information in this module, please click campus.tum.de or here.
Module Description


Version of module description: Gültig ab winterterm 2015/16

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Written assignment (ca. 15 pages) requiring review of literature, synthesis and integration of key concepts and findings from the literature to develop a coherent research proposal that clearly demonstrates knowledge in the field of species management and conservation strategies and of human dimensions as a research and applied field of study. Expected to read in advance where possible assigned readings so to be prepared for course lectures.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:

Intended Learning Outcomes:
After the course students are able to: understand important ecological concepts in wildlife management; understand the importance of the human dimension in wildlife management; analyse a conservation strategy for a species; apply wildlife management plans; evaluate species
and protected area management plans; understand the importance and nature of objectivity in conducting research and being a human dimension researcher; develop the ability to synthesize relevant literature pertinent to a research problem; organize ideas effectively and communicate these in a well-organized and developed written proposal.

**Teaching and Learning Methods:**
Lecture, video, group exercises, discussions

**Media:**
lecture notes, flip-chart/board, hand-outs, additional reading material

**Reading List:**

**Responsible for Module:**
Kühn, Ralph; Apl. Prof. Dr. agr. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Course 1:
Wildlife Management
Course 2:
Wildlife-Human Interactions

Lecturer 1:
Thomas Rödl
Lecturer 2:
Alistair James Bath

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description

WZ4207: Waste and Waste Water Treatment | Waste and Waste Water Treatment

Version of module description: Gültig ab winterterm 2020/21

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The written exam (90 min.) consists of general questions and simple calculations. In the written exam students demonstrate their theoretical knowledge of waste and wastewater treatment. The answers require wording but also single choice tests as well as calculations. Only the use of a calculator is allowed (closed book exam).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Interest and basic knowledge in chemistry, physics, biology and preferably in environmental, chemical, civil or process engineering. However, the level of the course is adapted to the known broad spectrum of background knowledge allowing also students to follow you hold a bachelor in a totally different realm.

Content:
Waste management:

1. Basics of waste management (What is waste, waste amounts, history and future of waste, waste legislation);
2. Avoidance and recovery of waste and waste management concepts;
3. Waste disposal (legal aspects of landfill, processes in above-ground landfill, above-ground landfill technologies, underground disposal sites);
4. Biological treatment (legal aspects, composting, fermentation, mechanical biological treatment, sewage sludge, substitute fuels);
5. Thermal treatment (legal aspect, thermal processes, equipment, power generation, alternative thermal processes, hazardous waste treatment).

Wastewater treatment:

1. Water treatment & management concepts; overview wastewater treatment steps
2. Wastewater characteristics & discharge limits
3. Mechanical wastewater treatment
4. Fundamentals in bioprocess technology; stoichiometry of biological reactions; kinetics of biological reactions; aeration
5. Biological wastewater treatment
6. Sewage sludge treatment
7. Field trip Garching wastewater treatment plant (optional)

Intended Learning Outcomes:
At the end of the module, students are able to:

1. Understand the necessity and objectives of waste management.
2. Understand the most important processes and technologies for waste treatment.
3. Decide which treatment method is valid for which type of waste.
4. Understand sources and types of emissions arising from waste treatment and measures for emission reduction
8. Understand the necessity and the feasibility of wastewater treatment especially in treating municipal wastewater.
9. Classify the single steps of eliminating wastewater compounds, such as coarse material, organic and inorganic pollutants.
10. Recall important treatment processes and their requirements.
11. Assess pros and cons of different treatment technologies.

Teaching and Learning Methods:
The knowledge in the field of waste management is imparted during lectures. Theoretical background is given and discussed at practical examples of existing waste management infrastructure (Collection Systems, Landfills, Treatment Facilities, etc.)

The content of the lecture are taught through practical examples. By means of example tasks in the lecture, possible solutions are discussed and exemplified calculations are performed. An optional field trip to the Garching wastewater treatment plant at the end of the course allows connecting theoretical knowledge with practical application and gives a final platform for questions.
Media:
The course is mainly taught by PowerPoint presentation and supported by notices on the black board. The lecture notes are uploaded to Moodle. It is ensured that further readings are available in the university library either for download or as hardcopy in an adequate number.

Reading List:
Waste Management:

Waste Management: https://issuu.com/tkverlag/docs/waste_management_4

Wastewater Treatment:

Responsible for Module:
Konrad Koch

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Module Description

WZ6432: Wildlife and Conservation Biology | Wildlife and Conservation Biology

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>150</td>
<td>75</td>
<td>75</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a 60 min. written exam (Klausur). The examination means to measure the student’s ability to assess anthropogenic influence on Biodiversity, to explain factors affecting Wildlife, to recall methods in Conservation Biology and applied Genetics and to evaluate Conservation Biology concepts. In the written examination students demonstrate by answering questions under time pressure and without helping material their theoretical and practical knowledge about Wildlife and Conservation Biology. For answering the questions, the students require their own wording. In the practical exercise the students present a case study and design a own research project proposal to practice their scientific communication skills and to transfer the theoretical knowledge to practical projects. Gradings from the Klausur and the Project work are weighed in the ratio 7:3.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Interest in Wildlife Conservation Biology and Nature Conservation. Basic background in Biology

Content:
The module combines the theoretical background and the practical implementation of Wildlife Conservation Biology, Conservation Genetics and Nature Conservation. The key aspects are:
1. Scope and tasks of Conservation Biology and applied Genetics
2. Biodiversity, Ecosystems, Ecosystem Services and Green Banking
3. Factors affecting terrestrial and aquatic Biodiversity
4. Methods in Wildlife Conservation Biology and applied Genetics
5. Conservation Biology concepts and strategies for natural population using international examples
6. Case studies and applied Nature Conservation, from theory to praxis
Intended Learning Outcomes:
At the end of the module students understand the importance of biodiversity of terrestrial resources and its interaction with human dimensions. They are able to apply and to evaluate Conservation Biology methods and strategies based upon an interdisciplinary understanding of species biology, conservation biology and applied genetics. In addition, students are able to integrate interdisciplinary knowledge into applied conservation management on a regional and international scale. They have an overview of applied interdisciplinary Nature Conservation management and are able to evaluate sustainable resource management strategies.

Teaching and Learning Methods:
The module combines the lecture "Wildlife and Conservation Biology" with an accompanying practical exercise "Case Studies in Nature Conservation". The lecture contents will be presented using lectures based on power-point presentation and group work in order to combine activating teaching methods with classic presentation techniques. In the accompanying practical exercise, the students will apply the gained theoretical knowledge by conducting case studies (research programs), and presenting own concepts of research project in various content in the field of Wildlife Conservation Biology and Nature Conservation. Here the students learn to independently screen the respective literature in this field and learn methods in science communication.

Media:
Form of presentation: lecture, case study, movie segment and practical exercise
material: lecture notes, flip-chart/board, plus different materials for methodological/technical training

Reading List:

Responsible for Module:
Kühn, Ralph; Apl. Prof. Dr. agr. habil.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click campus.tum.de or here.
Course Achievement | Studienleistungen

Module Description

WZ4061: Internship | Internship

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter/summer semester</td>
</tr>
</tbody>
</table>

Credits:* 12

Total Hours: 360

Self-study Hours: 360

Contact Hours: 0

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
After completion of the 8 weeks internship, the students have to submit an internship report (a 10 pages detailed report) and a confirmation of completion from the employer, in which the employer specify the duration of the internship (including potential time of absence).

With the report, the students demonstrate that they are able to review critically the operational structures and procedures, to develop independently project proposals, to evaluate subject specific tasks of principals and to reflect their personal competences for the practical work. They show additionally, that they can connect the different science issues of the Master’s program with the practical application in the job.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge in the field of sustainable resource management according to the science and management related outcomes of the Master’s Program.

Content:
The internship delivers insights into various fields of business activities concerning sustainable resource management and into specific operation procedures of enterprises or organizations. It provides the possibility to explore the career options and to contact potential employers. The students have to do their internship outside of enterprises of their own or of relatives with the minimum period of 8 subsequent weeks (12 ECTS credits).
The students have to look themselves for an internship and to plan it without getting in conflict with the lecture time. The recommended period for the internship is the lecture free time between the 2nd and 3rd semester (August – October). The internship can be split into two parts with a minimum duration of one month each. It is possible to do the internship in various organizations, however the minimum duration of one month each has to be kept.

The internship office can guide the selection of potential options. Those enterprises or organizations are recommended which are suitable as potential employers.

Organizational hints:
The processing of the internship has to be agreed with the internship office Weihenstephan. Contact the office in time, i.e. several weeks before starting. See: https://www.praktikantenamt-weihenstephan.bayern.de/237314/index.php
Before starting the internship, an internship contract has to be concluded. It has to cover 8 weeks, or if you split, minimum 4 subsequent weeks has to be done in the same enterprise.

The internship may be completed part-time for at least 20 hours per week. The total number of hours of 320 h must be completed in a part-time internship with correspondingly longer contract period.
If the internship is split up, the minimum duration per internship company is: 4 weeks x 40 h = 160 h, which must be completed at least per internship company. In the case of a part-time internship e.g. with 20 hours, at least 8 weeks must be completed per internship company.

**Intended Learning Outcomes:**
After the successful completion of the internship, the students are able to link theory and practice, especially
- to apply their scientific knowledge and management competences acquired in the master’s program into the practice in operational, strategic or scientific fields,
- to analyze and evaluate the functions and tasks of executive officers and managers in the area of sustainable resource management,
- to analyze and evaluate the operational, strategic and research related structures and procedures, and
- to develop independently project proposals.

Additionally, they are able to apply their social skills received, especially
- to integrate confidently in enterprises or organizations by performing a new job and
- to communicate with colleagues, supervisors and principals of enterprises or organizations in an adequate mode.

**Teaching and Learning Methods:**
The students take part in the daily routine in the enterprises or organizations during the internship.
According to the respective internship job, learning methods are applied like independently working on different tasks in the enterprise or organization, training of practical competences during the job execution, cooperating with the colleagues, supervisors and principals, implementing of tasks over a specific period, observing the mode of operation of principals and colleagues, writing documentation of own findings and experiences etc.

**Media:**
According to the internship job.

**Reading List:**
According to the internship job.

**Responsible for Module:**
Jositz-Pritscher, Ingrid, Dr. Praktikantenamt Weihenstephan www.praktikantenamt-weihenstephan.de Alte Akademie 1, 85354 Freising, 08161 / 71-3710 ingrid.jositz-pritscher@paw.bayern.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
For further information in this module, please click campus.tum.de or here.
Master's Thesis | Master's Thesis

Module Description

WZ2754: Master's Thesis | Master's Thesis

Version of module description: Gültig ab winterterm 2022/23

<table>
<thead>
<tr>
<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
<th>Frequency:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>English</td>
<td>one semester</td>
<td>winter/summer semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credits:*</th>
<th>Total Hours:</th>
<th>Self-study Hours:</th>
<th>Contact Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>900</td>
<td>890</td>
<td>10</td>
</tr>
</tbody>
</table>

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment in this module is based on the successful completion of the Master's Thesis (Research paper of around 100 pages depending on the topic) including the starting Master's Thesis Proposal (Report as coursework, 6 pages). In order to promote the competences required for the Master’s thesis, the proposal should be submitted before the registration of the thesis.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
The student selects a topic of his/her own choice on which he/she will work according to scientific methods. A combination of the master's thesis and an internship is possible if the rules for internships are kept. It would be ideal if student's master’s thesis is based on the internship experience. Discussing the topic and the methods with a guiding professor or lecturer before starting the master's thesis is absolutely necessary. Therefore, for all students a starting seminar "Master’s Thesis Proposal" is offered to guide them 1) theoretically in structuring their 6 months' work and 2) in practice in writing a proposal which outlines their thesis topic including the state of knowledge, the research gaps, the goal of the Master's Thesis, the planned methods, and a working and a financial plan. It also includes training on literacy strategy.

The thesis must be written under supervision of a tutor who must be a lecturer of TUM and has the approval to conduct exams at TUM. It is recommended to select a lecturer of the “Sustainable Resource Management” Program. The tutor will in the end evaluate and mark the master's thesis.
The thesis can be done at TUM, outside the university, abroad or in the student’s home-country, with previous consent of the tutor. Students can start writing their thesis in the fourth semester of the Master’s Program.

**Intended Learning Outcomes:**
After finishing the Master’s Thesis module, the students have the ability to work independently and adapt to a problem in a limited period of time. The theoretical and practical training received in the module enables our students to investigate defined scientific questions on their own, with support from an experienced supervisor. They can analyze and evaluate state-of-the-art knowledge, identify a research gap and work on derived specific research questions. To answer these questions and find solutions, they can subsequently plan and conduct experiments / study designs addressing the scientific question with appropriate research methods and techniques. The students know the most important facts and theories related to their research topic and can critically discuss and evaluate their own results in relation to the state-of-the-art knowledge. In conducting their art of science, they follow the rules of good scientific practice.

**Teaching and Learning Methods:**
The learning activities cover theoretical and practical training by a scientific supervisor of the host institution. The master student is guided in literature search, scientific reading, solving problems, practicing, designing an experiment, creating a scientific proposal and a scientific thesis, constructive criticising their own work and revising it on basis of feedback, all parts under time constraints. Therefore, the learning methods are an introduction seminar to support a structured procedure and peer instructions for their individual work.

**Media:**
Dependent on the topic of the thesis; e.g. specialized literature, software

**Reading List:**
Dependent on the topic of the thesis

**Responsible for Module:**
Weber-Blaschke, Gabriele; Apl. Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Master's Thesis Proposal (Seminar, 1 SWS)
Weber-Blaschke G
For further information in this module, please click campus.tum.de or here.
### Alphabetical Index

| Soils and Soil Management | 79 |

### A

- **[WZ0246]** **Advanced Concepts and Methods in Urban Ecosystems** | Advanced Concepts and Methods in Urban Ecosystems | 121 - 123
- **[WZ2757]** **Advanced Environmental and Natural Resource Economics** | Advanced Environmental and Natural Resource Economics | 128 - 129
- **[CS0126]** **Advanced Seminar in Circular Economy and Sustainability Management** | Advanced Seminar in Circular Economy and Sustainability Management [ASCESM] | 119 - 120
- **[WZ2721]** **Agriculture Raw Materials and their Utilization** | Agriculture Raw Materials and their Utilization [ARM&U] | 63 - 64
- **[WZ2721]** **Agriculture Raw Materials and their Utilization** | Agriculture Raw Materials and their Utilization [ARM&U] | 124 - 125
- **[WZ2736]** **Analytical Characterization of Soil Resources** | Analytical Characterization of Soil Resources | 85 - 86
- **[WZ2736]** **Analytical Characterization of Soil Resources** | Analytical Characterization of Soil Resources | 126 - 127
- **[BGU38019]** **Anaerobic Processes and Energy Recovery** | Anaerobtechnik und Energierückgewinnung | 117 - 118

### B

- **[IN2124]** **Basic Mathematical Methods for Imaging and Visualization** | Grundlegende Mathematische Methoden für Imaging und Visualisierung | 171 - 173

### C

- **[BGU62039]** **Case Studies of Sustainable Urban Developments and Infrastructure** | Fallstudien nachhaltiger Quartiers-, Stadt- und Infrastrukturentwicklungen [FNQSI] | 158 - 160
- **[WZ1590]** **Climate Change Economics** | Climate Change Economics | 133 - 135

[WZ001204] Economics of Water Use, Regulation and Markets | Economics of Water Use, Regulation and Markets 146 - 148

Elective Courses | Wahlmodule 29


[POL62200] Energy Transformation | Energy Transformation 138 - 140

[BGU38023] Engineered Natural Treatment Systems | Natürliche Aufbereitungsverfahren 197 - 198

[WZ1876] Entrepreneurship in the Agricultural and Horticultural Industry | Entrepreneurship in the Agricultural and Horticultural Industry 102 - 104

[WZ1876] Entrepreneurship in the Agricultural and Horticultural Industry | Entrepreneurship in der Agrar- und Gartenbauwirtschaft 151 - 153

[WZ000286] Environmental and Natural Resource Economics | Environmental and Natural Resource Economics 144 - 145

[WZ2732] Environmental Monitoring and Data Analysis | Environmental Monitoring and Data Analysis 75 - 76

[WZ2732] Environmental Monitoring and Data Analysis | Environmental Monitoring and Data Analysis 156 - 157

[SOT86700] EuroTeQ Collider - Leave no Waste Behind (Master) | EuroTeQ Collider - Leave no Waste Behind (Master) 141 - 143
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>WZ0228</td>
<td>Exercises in Precision Agriculture and Plant Phenotyping</td>
<td>149 - 150</td>
</tr>
<tr>
<td>WZ4189</td>
<td>Fisheries and Aquatic Conservation</td>
<td>44 - 46</td>
</tr>
<tr>
<td>WZ4098</td>
<td>Forestry Raw Materials and their Utilization</td>
<td>65 - 66</td>
</tr>
<tr>
<td>WZ2716</td>
<td>Forest Growth and Forest Operations</td>
<td>31 - 33</td>
</tr>
<tr>
<td>WZ2716</td>
<td>Forest Growth and Forest Operations</td>
<td>161 - 163</td>
</tr>
<tr>
<td>WZ4161</td>
<td>Forest Management</td>
<td>29 - 30</td>
</tr>
<tr>
<td>WZ4161</td>
<td>Forest Management</td>
<td>166 - 167</td>
</tr>
<tr>
<td>G</td>
<td>Free Elective Modules</td>
<td>117</td>
</tr>
<tr>
<td>WZ2714</td>
<td>General Education Subject</td>
<td>25</td>
</tr>
<tr>
<td>WZ2717</td>
<td>Genetic Resources Management and Forest Protection</td>
<td>34 - 36</td>
</tr>
<tr>
<td>WZ2717</td>
<td>Genetic Resources Management and Forest Protection</td>
<td>174 - 176</td>
</tr>
<tr>
<td>CLA20710</td>
<td>Global Diversity Training</td>
<td>27 - 28</td>
</tr>
<tr>
<td>WZ1545</td>
<td>Human Resource Management in Agriculture and Related Industries</td>
<td>177 - 178</td>
</tr>
<tr>
<td>WZ2731</td>
<td>Hydrometeorology and Management of Water Resources</td>
<td>71 - 72</td>
</tr>
<tr>
<td>Module Code</td>
<td>Course Title</td>
<td>Credits</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>WZ2731</td>
<td>Hydrometeorology and Management of Water Resources</td>
<td>179 - 180</td>
</tr>
<tr>
<td></td>
<td>Hydrometeorology and Management of Water Resources</td>
<td></td>
</tr>
<tr>
<td>E170860</td>
<td>Integration of Renewable Energies [IRE]</td>
<td>69 - 70</td>
</tr>
<tr>
<td>E170860</td>
<td>Integration of Renewable Energies [IRE]</td>
<td>181 - 182</td>
</tr>
<tr>
<td>E17467</td>
<td>Interdisciplinary Project Internship Concept Development of a Renewable Energy System in a Developing Country [ProRESDC]</td>
<td>183 - 185</td>
</tr>
<tr>
<td>LS50000</td>
<td>International Climate Strategies / UNFCCC</td>
<td>186 - 188</td>
</tr>
<tr>
<td>WZ4061</td>
<td>Internship</td>
<td>285 - 287</td>
</tr>
<tr>
<td>WZ1822</td>
<td>Introduction to Economics and Business Ethics</td>
<td>20 - 22</td>
</tr>
<tr>
<td>POL40100</td>
<td>Introduction to Politics &amp; Technology</td>
<td>230 - 231</td>
</tr>
<tr>
<td>WZ1823</td>
<td>Inventory Methods, Statistics and GIS</td>
<td>17 - 19</td>
</tr>
<tr>
<td>WZ2733</td>
<td>Introduction to Soil Science</td>
<td>79 - 80</td>
</tr>
<tr>
<td>WZ2733</td>
<td>Introduction to Soil Science</td>
<td>189 - 190</td>
</tr>
<tr>
<td>WZ1823</td>
<td>Inventory Methods, Statistics and GIS</td>
<td>17 - 19</td>
</tr>
</tbody>
</table>

L

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>WZ4094</td>
<td>Landscape Management - Application Study</td>
<td>56 - 57</td>
</tr>
<tr>
<td>WZ4094</td>
<td>Landscape Management - Application Study</td>
<td>191 - 192</td>
</tr>
<tr>
<td>WZ2719</td>
<td>Landscape Planning</td>
<td>51 - 52</td>
</tr>
<tr>
<td>WZ2719</td>
<td>Landscape Planning</td>
<td>205 - 206</td>
</tr>
<tr>
<td>WI001255</td>
<td>Lecture Series Renewable Energy Systems in the Global South</td>
<td>232 - 234</td>
</tr>
<tr>
<td>Title</td>
<td>Module Number</td>
<td>Pages</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Management and Protection of Forest Ecosystems</td>
<td></td>
<td>29</td>
</tr>
<tr>
<td>Management Aspects</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Master's Thesis</td>
<td>[WZ2754]</td>
<td>288 - 289</td>
</tr>
<tr>
<td>Material and Waste Management</td>
<td></td>
<td>87</td>
</tr>
<tr>
<td>[WZ2713] Methods of Scientific Communication</td>
<td></td>
<td>14 - 16</td>
</tr>
<tr>
<td>[WZ2722] Mountain Catchments under Changing Climate</td>
<td></td>
<td>73 - 74</td>
</tr>
<tr>
<td>[WZ2722] Mountain Catchments under Changing Climate</td>
<td></td>
<td>193 - 194</td>
</tr>
<tr>
<td>[WZ1821] Natural Resources - Traits, Management and Theory of</td>
<td></td>
<td>10 - 11</td>
</tr>
<tr>
<td>Sustainability</td>
<td>[WI001215]</td>
<td>114 - 116</td>
</tr>
<tr>
<td>Network and stakeholder analysis: Sustainable resource use and</td>
<td></td>
<td>202 - 204</td>
</tr>
<tr>
<td>agri-food system</td>
<td>[WZ4082]</td>
<td>37 - 39</td>
</tr>
<tr>
<td>Plantation Forestry and Agroforestry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| [WI001205] People in Organizations: Managing Change and Sustainability |              | 210 - 212   |
| in Agribusiness and the Food Industry                                |              |             |
| [WZ4082] Plantation Forestry and Agroforestry                       |              |             |</p>
<table>
<thead>
<tr>
<th>Code</th>
<th>Module</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>WZ4082</td>
<td>Plantation Forestry and Agroforestry</td>
<td>213 - 215</td>
</tr>
<tr>
<td>WZ4202</td>
<td>Political and Social Perspectives of Renewable Resources</td>
<td>67 - 68</td>
</tr>
<tr>
<td>WZ4202</td>
<td>Political and Social Perspectives of Renewable Resources</td>
<td>218 - 219</td>
</tr>
<tr>
<td>CLA11301</td>
<td>Presentation Training with Video Feedback</td>
<td>25 - 26</td>
</tr>
<tr>
<td>EI74831</td>
<td>Project Lab Renewable and Sustainable Energy Systems</td>
<td>207 - 209</td>
</tr>
<tr>
<td>WZ2712</td>
<td>Project Management and Cross Cultural Communication</td>
<td>23 - 24</td>
</tr>
<tr>
<td>WZ4197</td>
<td>Protected Areas Biodiversity and Management</td>
<td>40 - 41</td>
</tr>
<tr>
<td>WZ4197</td>
<td>Protected Areas Biodiversity and Management</td>
<td>216 - 217</td>
</tr>
<tr>
<td>LS10007</td>
<td>Remediation of Contaminated Sites – Lecture and Seminar</td>
<td>225 - 226</td>
</tr>
<tr>
<td>WZ2737</td>
<td>Remote Sensing and Image Processing</td>
<td>53 - 55</td>
</tr>
<tr>
<td>WZ2737</td>
<td>Remote Sensing and Image Processing</td>
<td>240 - 242</td>
</tr>
<tr>
<td>LS10003</td>
<td>Remote Sensing of Agriculture and Vegetation</td>
<td>220 - 221</td>
</tr>
<tr>
<td>WZ2720</td>
<td>Renewable Energy Technologies</td>
<td>61 - 62</td>
</tr>
<tr>
<td>WZ2720</td>
<td>Renewable Energy Technologies</td>
<td>238 - 239</td>
</tr>
<tr>
<td>WZ1674</td>
<td>Research Methods and Economic Research Project</td>
<td>235 - 237</td>
</tr>
<tr>
<td>LS10004</td>
<td>Research Project ‘Smart Agriculture’</td>
<td>222 - 224</td>
</tr>
<tr>
<td>LS20016</td>
<td>Rhizosphere Research</td>
<td>227 - 229</td>
</tr>
</tbody>
</table>
| Science Topics | Science Topics  
| WZ2734 Soil Protection | Soil Protection  
| WZ2734 Soil Protection | Soil Protection  
| WZ1921 Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry | Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry  
| WZ1921 Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry | Strategy, Supply Chain Management, and Sustainability in Agribusiness and the Food Industry  
| WZ1567 Sustainability: Paradigms, Indicators, and Measurement Systems | Sustainability: Paradigms, Indicators, and Measurement Systems  
| WZ1567 Sustainability: Paradigms, Indicators, and Measurement Systems | Sustainability: Paradigms, Indicators, and Measurement Systems  
| WZ2936 Sustainable Agricultural Value Chains | Sustainable Agricultural Value Chains  
| WZ2936 Sustainable and Environmental Regulations | Sustainable and Environmental Regulations  
| WI001165 Sustainable Entrepreneurship - Getting Started | Sustainable Entrepreneurship - Getting Started  
| ED160017 Sustainable Manufacturing | Nachhaltige Produktion [SuM]  
| ED160017 Sustainable Manufacturing | Nachhaltige Produktion [SuM]  
| WZ1824 System Analysis and Introduction to Ecology | System Analysis and Introduction to Ecology  
| WZ1344 Urban Agriculture | Urban Agriculture  
| WZ0528 Urban Forestry | Urban Forestry  
| BGU38038 Urban Water-Energy-Food Nexus | Urban Water-Energy-Food Nexus [WEF Nexus]  
| WZ2723 Utilization and Treatment of Special Materials and Waste | Utilization and Treatment of Special Materials and Waste  

Module Catalog of the study program M.Sc. Sustainable Resource Management
Generated on 12.12.2022