TUM School of Life Sciences
Technische Universität München

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 289

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 summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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

Description of Examination Method:
Aufgrund des Pandemiegeschehens hat der/die Studierende auch die Möglichkeit, an einer beaufsichtigten elektronischen schriftlichen Fernprüfung (Aufsicht mit Proctorio, 90 min.) teilzunehmen (Onlineprüfung: WZ1821o). Diese schriftliche Prüfung wird zeitgleich parallel in Präsenz angeboten (WZ1821).

The intended learning outcomes as defined below require a differentiated way of examination. A written exam 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, 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)
Biber P [L], Biber P, Grambow M, Häberle K, Kasperidus H, Knoke T, Kohlpaintner M, Kunkowski T, Menzel A, Pretzsch H, Savage C, Schad P, Teixeira Pinto L
For further information in this module, please click campus.tum.de or here.

Module Description

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

Version of module description: Gültig ab summerterm 2015

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:**	**Contact Hours:**

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 [L], Thejls Ziegler M
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 110	**Contact Hours:** 70

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.
4. Statistics in Resource Management: Justification of statistics, descriptive statistics and exploration: Frequencies and their graphical representation, distributions and their moments, testing hypotheses, regression analysis, post hoc tests, a priori contrasts, analysis of variance.

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:
Environmental Systems Research Institute Inc.: Map Projections. Georeferencing spatial data, ESRI Press * Zeiler, M.: Modelling Our World. The ESRI Guide to Geodatabase Design, ESRI Press * Vienneau, A.: Using ArcCatalog, ESRI Press * Minami, M.;Sakala, M.;Wrightsell, J.: Using ArcMap, ESRI Press * Terrestrial Inventory Methods: Gregoire TG and Valentine HT (2008) Sampling strategies for natural resources and the environment. Boca Raton, Fla.; London, Chapman & Hall/CRC * Mandallaz D (2008) Sampling techniques for forest inventories. Applied Environmental Statistics. Chapman and Hall. 276 p * Introduction to Remote Sensing Principles: Richards, J.A., Jia, X.: Remote Sensing Digital Image Analysis - an introduction; Springer Press, Principles of Remote Sensing - an introductory textbook; Ed. L.L.F. Janssen, G.C. Huurneman, ITC educational textbook series; internet tutorials from ESA, DLR, NASA, CCRS, etc. * Statistics with Microsoft Excel (4th Edition) by Beverly Jean Dretzke (Paperback - June 20, 2008) *Discovering statistics using SPSS Field, Andy P. 2009

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

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

Statistics (Vorlesung, 1 SWS)
Knoke T

Inventory Methods (Vorlesung, 2 SWS)

Knoke T, Schneider T
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 summerterm 2015

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 which 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 about scientific communication including scientific writing, presentation and reflecting differentiated into 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 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 an own presentation (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 supposed to finish them individually as homework. In group work as in reality concerning the process of scientific writing the students have to study specialist literature and data files which are the basis for writing the scientific paper as homework under time constraint. On basis of critique (review) by the lecturer they have to revise the scientific paper. As complement every student has to prepare and hold oral presentations in the seminar.

Media:
Power point presentation, black board, flip chart, pin board, lecture sheets, PDFs of scientific papers, PDFs of Guidelines.

Reading List:
Summary guideline "How to write a scientific paper" within the seminar.
Day, R.A.; Gastel, B.; 2012: How to write & publish a scientific paper. 7th edition, 2012, Cambridge University Press, pp. 300
Huss, J.; 2014: Schreiben und Präsentieren in den angewandten Naturwissenschaften. Ein Leitfaden. 2. Auflage. 256 Seiten. Verlag Kessel, Remagen-Oberwinter 2014. ISBN 978-3-941300-94-1.

Responsible for Module:
Apl.-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:
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

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

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 4	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
Aufgrund des Pandemiegeschehens hat der/die Studierende auch die Möglichkeit, an einer beaufsichtigten elektronischen schriftlichen Fernprüfung (Aufsicht mit Proctorio, 90 min.) teilzunehmen (Onlineprüfung: WZ1824o). Diese schriftliche Prüfung wird zeitgleich parallel in Präsenz angeboten (WZ1824).

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:
Begon, M., C. R. Townsend and J. L. Harper. 2006. Ecology: From Individuals to Ecosystems. Blackwell Publishing, Malden, MA.
Ford, A. Modeling the Environment. Island Press, 1999.
Sterman, J.D., Business Dynamics. McGraw-Hill Education, 2000.

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)

Meyer S [L], Meyer S, Heinen R, Weißer W, Mimet A, Achury Morales R, Biddick M, Novella Fernandez R
For further information in this module, please click campus.tum.de or here.

Module Description

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

Version of module description: Gültig ab summerterm 2015

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** irregularly
Credits:* 1	**Total Hours:** 30	**Self-study Hours:** 7	**Contact Hours:** 23

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 Körpertechnik, 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:
Brillant Präsentieren - live & vor der Webcam (Online Medientraining für deinen überzeugenden Auftritt) (Workshop, 1,5 SWS)
Bell I
For further information in this module, please click campus.tum.de or here.

Elective Courses | Wahlmodule

Fields of Specialization | Vertiefungsbereiche

Environmental Economics and Policy | Environmental Economics and Policy

Module Description

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

Version of module description: Gültig ab summerterm 2017

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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.

Jaeger, W.K. (2005): Environmental Economics. Island Press.
Mankiw, N.G. and M.P. Taylor (2011): Microeconomics. 2nd Edition. South Western.
Perman, R., Y. Ma, J. McGilvray, M. Common (2003): Natural Resource and Environmental Economics. 3rd Edition. Pearson Education Limited.
Tietenberg, T. and L. Lewis (2010): Environmental Economics & Policy. Prentice Hall.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Environmental and Natural Resource Economics (WI000286) (Vorlesung mit integrierten Übungen, 4 SWS)
Glebe T
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 60	**Contact Hours:** 90

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:
Bréchet, T., & Eyckmans, J. (2009). Coalition theory and integrated assessment Modelling: Lessons for climate governance. Global Environmental Commons: Analytical and Political Challenges in Building Governance Mechanisms.
Rohling, M., & Ohndorf, M. (2012). Prices vs. quantities with fiscal cushioning. Resource and Energy Economics, 34(2), 169-187.
MacKenzie, I. A., & Ohndorf, M. (2012). Optimal monitoring of credit-based emissions trading under asymmetric information. Journal of regulatory economics, 42(2), 180-203.
Hake, J. F., Fischer, W., Venghaus, S., & Weckenbrock, C. (2015). The German Energiewende–history and status quo. Energy, 92, 532-546.
Climate Action Plan 2050 Principles and goals of the German government's climate policy. https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutzplan_2050_en_bf.pdf
EU ETS Handbook. https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf

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

Courses (Type of course, Weekly hours per semester), Instructor:
Climate Change Economics (WZ1590) (Vorlesung, 4 SWS)
Sauer J [L], Canessa C, Frick F
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Wintrobe, R. (2000): The Political Economy of Dictatorship, Cambridge University Press, Cambridge; Tremmel, J. (2006): Handbook of intergenerational justice, Edward Elgar, Cheltenham; Glasson, J., Therivel, R. & A. Chadwick (2019): Introduction to Environmental Impact Assessment. 5th edition. Routledge, London and New York: 394 pages; Sadler, B., Aschemann, R., Dusik, J, Fischer, T.B., Partidário, M.R. & R. Verheem (2011): Handbook of Strategic Environmental Assessment. Earthscan, London, Washington, DC. Additional material will be provided.

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.

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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
FAO (2018): State of the World's Forests; FAO (2016): Global Forest Resources Assessment 2015.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Forest Ecosystem Management (Vorlesung, 2 SWS)
Felbermeier B [L], Annighöfer P, Felbermeier B

Forest Management Planning (Übung, 3,5 SWS)
Knoke T, Bödeker K, Döllerer M, Gang B, Kienlein S, Pintado K
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 asthe forest growth modelling part of the lecture can be presented best in a written formby 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:
FOREST GROWTH: Pretzsch, H., (2009): Forest Dynamics, Growth and Yield. Springer Verlag, Berlin, 664 S. 2009 published as Hardcover(ISBN 978-3-540-88306-7) 2010 published as paperback (ISBN 978-3-642-14861-3) FOREST OPERATIONS: Bowers, S. 2012. Designing woodland roads. Oregon State University. EC 1137. 21 pp. Dykstra, D. P. and Heinrich, R. 1996. FAO Model code of forest harvesting practice. 85 pp. Enters, D., Applegate, G.B., Kho, P. C.S., and Man, G. (Eds.) 2002. Applying reduced impact logging to advance sustainable forest management. FAO. Heinrich, R. Recent developments on environmentally friendly forest road construction and wood transportation in mountainous forests. Rummer, B. 2009. New technology in forest operations. www.forestlandowners.com. 3 pp. Sutherland, B.J. 2003. Preventing soil compaction and rutting in the boreal forest of western Canada. FERIC. 53 pp.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Low Impact Forest Operations Technology (Exkursion, ,5 SWS)

Bauer E, Engler B

Low Impact Forest Operations (Vorlesung, 1,5 SWS)
Bauer E, Engler B

Forest Growth (Vorlesung, 2 SWS)
Pretzsch H, Rötzer T
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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;
- U 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
- kexplain 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:
Frankham, et al. 2017, Genetic Management of Fragmented Animal and Plant Populations, Oxford University Press; Allendorf et al. 2013, Conservation and the Genetics of Populations, Wiley-Blackwell; Agrios, G.N. 2005, Plant Pathology, 5th edition. Elsevier Academic Press, Oxford; Speight, M.R. & Wylie, F.R., 2001: Insect pests in tropical forestry. CABI publishing; Ruppert, E.E. & Barnes, R.D., 1993: Invertebrate Zoology 6th edition (Chapter 16 insects; p 825-862)

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 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
Aufgrund des Pandemiegeschehens wird die alternative Prüfungsform Klausur, schriftlich (90 min, WZ4082o) angeboten.

The learning outcomes are assessed by an oral examination. 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:
ABARE - JaakoPöyry (1999): Global Outlook for Plantations. Australian Bureau of Agricultural and Resource Economics (ABARE) Research Report 99.9, www.abare.gov.au. Evans, J., Turnbull, J. W. (2004): Plantation forestry in the tropics. FAO, (1998): FRA 2000 - Terms and definitions. Forest Resources Assessment Programme, Working Paper 1. FAO (2001): Global Forest Resources Assessment 2000. FAO Forestry Paper 140. Pandey, D. and Ball, J. (1998): The role of industrial plantations in future global fibre supplies. Unasylva 193, Vol. 49, 37 - 43. Sawyer, J., (1993): Plantations in the Tropics. Smith, D.M., Larson, B.C.,Kelty, M.J. and Ashton, P.M.S. (1997): The Practice of Silviculture: Applied Forest Ecology. Smith, J. (2002): Afforestation and reforestation in the clean development mechanism of the Kyoto protocol: implications for forests and forest people. Int. J. Global Environmental Issues 2 (3/4): 322-343. Shepherd, K.R. (1986): Plantation Silviculture. West, P. W. (2006): Growing Plantation Forests. Ashton, M.S. and Montagnini, F. (2000): The silvicultural Basis for Agroforestry Systems. Agroforesty: Principles and Practice: Special issue of Forest Ecology and Management, 45 (1991). Nair, P.K.R. (2012): Agroforestry, the future of global land use. Atangana et al. (2014): Tropical Agroforestry. Springer Verlag

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, Günter S

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 2020

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 word 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:
Jürgen Schultz (2005): The Ecozones of the World: Ecological Divisions of the Geosphere. Springer, Berlin. 459p.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Biodiversity in Protected Areas (Vorlesung, 2 SWS)
Kühn R [L], Gula R, Rödl T

Protected Area Management (Vorlesung, 2 SWS)
Kühn R [L], Gula R, Rödl T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ4198: Wildlife Management and Wildlife-Human Interactions | Wildlife Management and Wildlife-Human Interactions

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
This lecture combines contents of Wildlife Management and Wildlife Human Interactions. The key aspects are: 1) Principles of Wildlife Management & Wildlife Science, 2) Planning tools, 3) Case study: Strategic planning, 4) Conflicting views in WMT with case studies, 5) Basic Concepts in Ecology, 6) Reintroductions studies, 7) Global threats to Conservation, 8) Nature of human dimensions (HD) from a research perspective through various examples 9) Nature of various wildlife-human interactions from different perspectives, 10) Nature of public involvement and HD as an applied approach 11) Types of conflict, levels of planning and how to work with people toward solutions, 12) Understanding decision-making processes.

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:
Sinclair et al. 2006, Wildlife Ecology, Conservation, and Management, ISBN 1-4051-0737-5 ; Krausman 2002, Wildlife Management, ISBN 0-1328-0850-1; Pullin 2002, Conservation Biology, ISBN 0-521-64482-8

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

Courses (Type of course, Weekly hours per semester), Instructor:
Wildlife-Human Interactions (Seminar, 2 SWS)
Kühn R [L], Bath A

Wildlife Management (Vorlesung, 2 SWS)
Kühn R [L], Rödl T
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 summerterm 2020

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

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 Biodiversty, 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.

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 Bankiing
3. Factors affecting terrestrial and aquatic Biodiversty
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 Biodiverstiy of terrestial 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 excercise " 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 excercise, 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 excercise
material: lecture notes, flip-chart/board, plus different materials for methodological/technical training

Reading List:
1. Primack (2014) Essentials of Conservation Biology 2. Frankham (2010) Introduction to Conservation Genetics 3. Sutherland (2009) Conservation Science and Action

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

Courses (Type of course, Weekly hours per semester), Instructor:
Conservation Biology and Applied Genetics (Vorlesung, 2 SWS)
Kühn R

Case Studies in Nature Conservation (Übung, 3 SWS)
Kühn R, Stoeckle B
For further information in this module, please click 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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 (hygienie, 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 overexpoitation 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 excercise the students prepare a presentation in form of a broschure, 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
2. Helfman (2007) Fish Conservation: A guide to understanding and restoring global aquatic biodiversity and fishery
resources
3. Moyle & Cech (2004) Fishes An introduction to Ichtyology
4. Primack (2008) A primer of conservation biology

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], Bayerl H, Geist J, Pander J, Stoeckle B, Zingraff-Hamed A
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 summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
Aufgrund des Pandemiegeschehens wird die alternative Prüfungsform unbeaufsichtigte elektronische Fernprüfung
(90 min. Moodle-Upload, Online-Prüfung: WZ4201o) angeboten.

A written exam of 90 minutes 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 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, Statistics and GIS".
Basic knowledge of population biology, community and ecosystem ecology.

Content:
GIS:
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
9. Management measures for management plans

Vegetation Ecology:
1. Vegetation ecology: overview, historical notes and outline;
2. Vegetation and the environment: classification of natural & semi-natural vegetation;
3. Clonality in plant communities & seed ecology and assembly rules in plant communities;
4. Species interactions structuring plant communities;
5. Vegetation and the ecosystem & vegetation dynamics;
6. Plant functional types and traits & diversity and ecosystem function;
7. Vegetation conservation, management and restoration;
8. Plant invasions and invasibility of plant communities;
9. Vegetation mapping: vegetation types and scales, from landscape to regional;
10. Practical aspects of vegetation sampling and classification.

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
• Understand the basic principles for the study of plant communities
• Identify vegetation types and describe its main aspects
• Apply different methods of vegetation sampling and classification

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 fieldwork and presentation of proposals for landscape management measures.

Introduction of theoretical and methodological aspects related to vegetation ecology studies, classification of vegetation types and practical aspects regarding the discipline.

Media:
GIS Software, PowerPoint Presentations, Instruction videos.

Reading List:
Vegetation Ecology, 2nd edition (Edited by Eddy van der Maarel & Janet Franklin)
Vegetation Ecology of Central Europe, vol. I and II (by Christoph Leuschner & Heinz Ellenberg)
Global Vegetation – Fundamentals, Ecology and Distribution (by Jörg S. Pfadenhauer & Frank A. Klötzli)
The Ecology of Plants (by Jessica Gurevitch)
Vegetation Description and Data Analysis – A Practical Approach, 2nd edition (by Martin Kent)
From Plant Traits to Vegetation Structure – Chance and selection in the assembly of ecological communities (by Bill Shipley)
Data Analysis in Vegetation Ecology, 3rd edition (by Otto Wildi)

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

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

Vegetation Ecology (Vorlesung, 2 SWS)
Teixeira Pinto L
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Haaren, C. v., Lovett, A. & C. Albert (2019): Landscape Planning with Ecosystem Services – Theories and Methods for Application in Europe. Springer Nature, Dordrecht. Additional material will be provided.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Landscape Planning - lecture (Vorlesung, 2 SWS)
Augenstein I

Landscape Planning - seminar (Seminar, 2 SWS)
Augenstein I
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 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 95	**Contact Hours:** 75

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

Description of Examination Method:
The assessment is based on: 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:
TThe 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, Schneider T, Teixeira Pinto L
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 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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. 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:
The implementation of data interpretation and information extraction concepts and techniques is trained "hands on" with the help of advanced image processing and analysis programs. Topics: 1. Introduction to image processing concepts; 2. Implications of air- and space borne data takes; 3. Data types: Digital aerial photographs, high to very high resolution multispectral and hyperspectral scanner data, LIDAR data; 4. Development of interpretation keys; 5. Exercises on data pre-processing; 6. Unsupervised and supervised classification concepts, pixel-based, object based classification strategies; 7. Exercises on land use/land cover classification; 8. Basic verification concepts; 9. Exercises on the extraction of bio-geo-chemo-physical parameter from RS data; 10. Change detection concepts; 11. Interrelation of Remote Sensing with GIS; 12. Access and data download from geodata provider.

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:
The literature recommended within the Modules "Inventory Methods and GIS", "Remote Sensing and Image Processing", www.wiau.man.ac.uk/courses/cvmsc/Terminol.htm#SplitMerge;http://www.pfc.cfs.nrcan.gc.ca/landscape/inventory/wulder/large_area_rs/index.html; http://www.pfc.cfs.nrcan.gc.ca/landscape/inventory/wulder/hirespres.html; Uni Zürich, RSL: http://www.geo.unizh.ch/rsl2/; EARSeL: http://www-earsel.cma.fr/; http://www.ccrs.nrcan.gc.ca/ccrs/

eduref/tutorial/indexe.html; http://observe.ivv.nasa.gov/nasa/education/reference/main.html; http://rst.gsfc.nasa.gov/starthere.html

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, Schneider T
For further information in this module, please click campus.tum.de or here.

Renewable Resources | Renewable Resources

Module Description

WZ2720: Renewable Energy Technologies | Renewable Energy Technologies

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 (Vorlesung, 4 SWS)
Wieland C [L], Wieland C
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Hijazi, O; Munro, S; Zerhusen, B; Effenberger, M. (2016): Review of life cycle assessment for biogas production in Europe. Renewable and Sustainable Energy Reviews (54), 1291-1300.

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

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

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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, 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:
Fengel, D.; Wegener, G. (2003): Wood - Chemistry, Ultrastructure, Reactions. Kessel Publishers
Dinwoodie, J.M. (2000): Timber: Its nature and behaviour. Van Nostrand Reinhold Publishers
Forest Products Laboratory (ed) (2010): Wood as an Engineering Material: http://www.fpl.fs.fed.us-documnts-FPLGTR-fplgtr.113-PL113.htm.
Rowell R. ed. (2012): Handbook of Wood Chemistry and Wood Composites. Sec. Edition, CRC Press Taylor & Francis Group, 703 pp.
Shmulsky, R., Jones P.D (2011): Forest Products & Wood Science, 6th ed. Wiley-Blackwell, Chichester UK

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:
Forestry Raw Materials and their Utilization (Vorlesung, 2 SWS)
Richter K, van de Kuilen J, Sanchez-Ferrer A

Forestry Raw Materials and their Utilization (Übung, 2 SWS)
Richter K, van de Kuilen J, Sanchez-Ferrer A
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

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, Westermayr M
For further information in this module, please click campus.tum.de or here.

Material and Waste Management | Material and Waste Management

Module Description

WZ4206: Material Flow Management and Applications | Material Flow Management and Applications

Version of module description: Gültig ab winterterm 2018/19

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

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:
Brunner, P.H., Rechberger H. (2004): Practical Handbook in Material Flow Analysis. Advanced Methods in Resource and Waste Management. Lewis Publishers, Boca Raton, pp. 318.
Brunner, P.H.; Rechberger, H.; 2016: Handbook of Material Flow Analysis: For Environmental, Resource, and Waste Engineers. Taylor & Francis Inc; 2. Revised Edition, pp. 453
Weber-Blaschke, G.; 2009: Stoffstrommanagement als Instrument nachhaltiger Bewirtschaftung natürlicher und technischer Systeme. Ein kritischer Vergleich ausgewählter Beispiele. Schriftenreihe „Nachwachsende Rohstoffe in Forschung und Praxis“ des Wissenschaftszentrums Straubing, Bd. 1, Verlag Attenkofer, Straubing, 330 S.

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:
Material Flow Management and Application (Vorlesung, 3 SWS)
Weber-Blaschke G [L], Weber-Blaschke G
For further information in this module, please click campus.tum.de or here.

Module Description

WZ4207: Waste and Waste Water Treatment | Waste and Waste Water Treatment

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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. Asses 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:
Bilitewski, B., Härdtle, G., Marek, K.; Weissbach, A.; Boedekker, A.: Waste Management, Springer-Verlag Berlin Heidelberg, ISBN-10: 9783642082122

Waste Management: https://issuu.com/tkverlag/docs/waste_management_4
Evans, G. (Ed): Biowaste and Biological Waste Treatment, ISBN: 978-1-902916-08-8

Wastewater Treatment:
la Cour Jansen, J., Arvin, E., Henze, M., Harremoes, P., 2019. Wastewater treatment - Biological and chemical Processes. Polyteknisk Boghandel og Forlag, Lyngby.
Tchobanoglous, G., Burton, F.L., Tsuchihashi, R., Stensel, H.D., 2013. Wastewater Engineering: Treatment and Resource Recovery. McGraw-Hill, Boston.
Wiechmann, B., Dienemann, C., Kabbe, C., Brandt, S., Vogel, I., Roskosch, A., 2013. Sewage sludge management in Germany. Umweltbundesamt, Bonn.

Responsible for Module:
Konrad Koch

Courses (Type of course, Weekly hours per semester), Instructor:
Waste Management (Vorlesung, 2 SWS)
Franke M

Waste Water Treatment (Vorlesung, 2 SWS)
Koch K
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 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 120	**Contact Hours:** 30

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. 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:
Oreopoulou V.; Russ W. (2007): Utilization of By-Products and Treatment of Waste in the Food Industry, Springer; New York.
Additional literature depending on themes.

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:
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

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

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

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. 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 Engeneering 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)
Lichti F, Neser S
For further information in this module, please click campus.tum.de or here.

Agricultural Land-Use Systems | Agricultural Land-Use Systems

Module Description

WZ2725: Land-Use Systems from Local and Global Perspectives | Land-Use Systems from Local and Global Perspectives

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 exam (duration: 30 minutes).
In this form of exam the students can show how they are able to explain the farming systems and describe the elements and farming methods. Due to a deeper discussion the examiner is able to evaluate the students under-standing of farm practices, system concepts and interactions with site conditions.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
Basic information on farming: crops, crop rotations, permanent crops: hops and orchards; soil management, weed management; implements and machinery; organic and mineral fertilizers; pesticide use; livestock: animal husbandry, breeding criteria; consumer expectations; exemplified by Bavarian and German cases.
Introduction to farming systems worldwide: pastoral systems, permanent crops plantation systems, mixed systems, arable systems, intensive animal keeping; horticultural systems; students experience with agricultural land use in their countries.

Intended Learning Outcomes:
On successful completion of the module students are able to remember and identify different crops, farm animals, machines and implements. They will be able to describe farming systems

esp. the difference of organic and conventional systems. They will understand farm management methods and interactions inside farming systems. The students can classify land-use systems worldwide and are able to explain the main elements and to evaluate the sustainability and resource impact.

Teaching and Learning Methods:
Lectures providing theoretical foundations. Examples will be given during the lectures.
Short field trips to farms and university research station, demonstrating crops, animals, technical equipment.
Short discussion sessions.

Media:
Power Point.

Reading List:
Tba

Responsible for Module:
Dr. Hans-Jürgen Reents; Dipl. Ing. Max Kainz - Lehrstuhl für Ökologischen Landbau und Pflanzenbausysteme Liesel Beckmann Str. 2, 85354 Freising, 08161/71 - 3778, reents@wzw.tum.de, kainz@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

WZ2726: Assessment of Sustainability in Agriculture - Theory and Case Studies | Assessment of Sustainability in Agriculture - Theory and Case Studies

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
The Assignment (Report+Assessment) is done as groupwork (2-3 students). As the report and assessment is based on a farm visit and to register presented details and understand the complexity of the system group working is necessary. The assignment shows the ability of the students to describe the farming system, to apply the developed criteria of sustainable agricultural practice, to assess the sustainability of farm as a system and to give recommendations for an improved development.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
Sustainability in farms context, principles of sustainability, criteria, inquiry strategies, indicator and indicator concepts, assessment and benchmarking.
Application to farming systems and farms at different level of intensification; case studies based on excursions: arable farming, organic vs. conventional farming, vegetable production in arable farms, grassland based farming system, dairy farming, suckling beef production.

Intended Learning Outcomes:
On successful completion of the module students are able to understand the idea of sustainability in the context of farms. They will have the ability to create criteria and indicators to assess sustainability of farms and to built up benchmarking systems. The students can describe farming

systems and are able to evaluate the sustainability using criteria and indicators and to document them in a report.

Teaching and Learning Methods:
Lectures with presentation of principles and systematics
Reading papers
Group work, mind mapping, meta plan technical to document discussion results.

Media:
Power Point, Flip Chart, Pin wall, Metaplan technic

Reading List:
Tba

Responsible for Module:
Dipl. Ing. Max Kainz; Dr. Hans-Jürgen Reents - Lehrstuhl für Ökologischen Landbau und Pflanzenbausysteme, Liesel Beckmann Str. 2, 85354 Freising, 08161/71 - 3778, kainz@wzw.tum.de, reents@wzw.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Assessment of Sustainability in Agriculture- Theory and Case Studies
Hans-Jürgen Reents, Max Kainz
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2727: Sustainability of Food Chains | Sustainability of Food Chains

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
Combination of Poster and oral presentation provides to assess the students ability to conduct a life cycle analysis of a special food product. The poster needs a very concentrated presentation, focus on the important information and factors and shows the students capability to understand the principles of the LCA and the special food production process.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Attendance in Module 4209 and 4210 is recommended.

Content:
Food chains of processed food, from agricultural production via processing to packed product unit in a food store, principles of life cycle analysis, assessment criteria, energy input output ratio, energy efficiency, CO2 emission, carbon footprint, virtual water
LCA calculation and calculation program (Umberto).

Intended Learning Outcomes:
At the end of the module the students are able to understand food chains. They can describe and apply life cycle analysis to processed food products. They are able to assess energy and emission impact of different crop and animal production system and processing procedures. The will get basic skills of the software Umberto.

Teaching and Learning Methods:
Teachers Presentations Life cycle analysis, food chain, energy, CO2 emission and water impacts, students contributions, special aspects of processing paper reading for contributions to group discussions and outline of the final presentation.

Media:
Presentation notes, computer program.

Reading List:
Tba

Responsible for Module:
Dipl. Ing. Max Kainz - Lehrstuhl für Ökologischen Landbau und Pflanzenbausysteme Liesel Beckmann Str. 2, 85354 Freising, 08161/71 - 3034, kainz@wzw.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Sustainabilityof Food Chains
Max Kainz
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2728: Sustainable Land-Use Management | Sustainable Land-Use Management

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
In a Power Point (or comparable tool) supported oral presentation the students can show, how they identify a special issue of farm management related to terms of sustainability. In the further outline of the presentation, the students will show how to discuss the topic based on recorded results from published papers, to explain conclusions and to suggestsolutions on improved sustainability.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
Agricultural systems and their relation to natural and human resources; site, economic and social conditions, regional and global,
adaptation of farm management techniques to principles of sustainability, research and scientific results, terms of politics and social debate, aims and scenarios for future development
Topics selected participative with the students.

Intended Learning Outcomes:
On successful completion of the module students are able to identify special problems of sustainability in farm management, economic and social conditions, to analyze the technical, social and economic impacts and to evaluate them on the background of criteria of sustainability. They will be able to create solutions for critical impacts.

Teaching and Learning Methods:
Lectures provide facts, background and theoretical foundations.

Papers have to be read and used in group work.
Group work.

Media:
Power Point Presentations
Flip Chart
Pin wall, Metaplan technique

Reading List:
Tba

Responsible for Module:
Dipl. Ing. Max Kainz; Dr. Hans-Jürgen Reents - Lehrstuhl für Ökologischen Landbau und Pflanzenbausysteme, Liesel Beckmann Str. 2, 85354 Freising, 08161/71 - 3778, kainz@wzw.tum.de, reents@wzw.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Case Studies of Land-Use Management
Hans-Jürgen Reents, Max Kainz
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Ahrends (2000) Meteorology today, 7th edition. Jones JAA (2010) Water Sustainability - A Global Perspective, Hodder Education London. Clarke R & King J (2004) The atlas of water. Figueres C. et al. (2003) Rethinking water management. Wescoat JL et al. (2003) Water for life, water management and environmental policy. Grambow M (2008) Wassermanagement.

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:
Management of Water Resources (Vorlesung, 2 SWS)
Estrella N, Menzel A

Introduction to Hydrometeorology (Vorlesung, 2 SWS)
Menzel A [L], Estrella N, Menzel A
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 2020

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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:
IPCC (2013) Fifth Assessment Report; Shelton ML (2009): Hydroclimatology - Perspectives and Applications; IPCC (2008) Technical Paper VI on Climate Change and Water

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:
Introduction in Hydrological Modelling (Vorlesung, 2 SWS)
Chiogna G

Field Course in Applied Hydrometeorology (Vorlesung mit integrierten Übungen, 3 SWS)
Menzel A [L], Lüpke M, Menzel A
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 2020/21

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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

Description of Examination Method:
Aufgrund des Pandemiegeschehens hat der/die Studierende auch die Möglichkeit, an einer beaufsichtigten elektronischen schriftlichen Fernprüfung (Aufsicht mit Zoom, 180 min.) teilzunehmen (Onlineprüfung: WZ2732o). Diese Prüfung wird zeitgleich parallel in Präsenz angeboten (WZ2732).

Upon completion of the module, the students have a profound understanding of key aspects of environmental monitoringand 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, Krause A, Meyer B

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 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
Due to Corona, the form of examination has changed as follows.
Assessment consisting of excercises. In a written test (Klausur, duration 60min, 60% of the module grade) 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.
In three graded exercises 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. The students prepare a video in groups including a role play of a panel discussion to develop their persuasive and critical skills as organizers and presenters, they become more familiar with political decision-making processes. The video is presented and discussed with all students participating. The grade for the seminar counts 40% of the module it consists of three equally weighted grades for each exercise.

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 divers 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:
IPCC (2013) Fifth Assessment Report of WGI, II, III. Houghton (2015) Global warming, the complete briefing. Most recent scientific literature.

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, Ghada W

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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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:
Brady, Weil: The nature and properties of soils, 14th edition, 2007.
Blume et al.: Scheffer/SchachtschabelSoilscience, 2016.
Eash, Sauer, O'Dell, Odoi, Bratz: Soil science simplified, 6th edition, 2016.
Blum, Schad, Nortcliff: Essentials of Soil Science, 2016.
FAO Guidelines for Soil Description. Prepared by Jahn, Blume, Asio, Spaargaren, Schad, 2006.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Soil Science: Lecture (Vorlesung, 2 SWS)
Schweizer S

Introduction to soil science: Field course (Übung, 3,5 SWS)
Wiesmeier M [L], Wiesmeier M, Garcia Franco N, Völkel J, Putzhammer S, Schad P
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 kaolinitc 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:
Blanco, H., Lal, R. (2008): Principles of soil conservation and management. Diamond, J. (1998): Guns, germs and steel. A short history of everybody for the last 13,000 years. Mirsal, I. (2008): Soil Pollution.

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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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:
FAO Guidelines for Soil Description. Prepared by Jahn, Blume, Asio, Spaargaren, Schad, 2006.
IUSS Working Group WRB: World Reference Base for Soil Resources 2014. Update 2015. 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:
World Soil Resources: Lecture (Vorlesung, 2 SWS)
Schad P

Bodenansprache und Bodenklassifikation nach internationalen Standards (Übung, 2,8 SWS)
Schad P
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2736: Analytical Characterization of Soil Resources | Analytical Characterization of Soil Resources

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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)
Prietzel J, Schweizer S, Bucka F, Göttlein A, Kolb E, Laniewski R, Leemhuis S

Analytical characterization of soil resources: Lecture (Vorlesung, 1 SWS)
Schweizer S
For further information in this module, please click campus.tum.de or here.

Elective Modules | Elective Modules

Module Description

BGU38019: Anaerobic Processes and Energy Recovery | Anaerobtechnik und Energierückgewinnung

Version of module description: Gültig ab winterterm 2018/19

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

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

o Agricultural use and incineration
o Recovery of phosphorous

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:
Appels, L., Baeyens, J., Degrève, J., Dewil, R., 2008. Principles and potential of the anaerobic digestion of waste-activated sludge. Prog. Energy Combust. Sci. 34, 755–781.
Chen, Y., Cheng, J.J., Creamer, K.S., 2008. Inhibition of anaerobic digestion process: A review. Bioresour. Technol. 99, 4044–4064.
Kelessidis, A., Stasinakis, A.S., 2012. Comparative study of the methods used for treatment and final disposal of sewage sludge in European countries. Waste Manag. 32, 1186–1195.
Roskosch, A., Otto, S., 2014. Technical Guide on the Treatment and Recycling Techniques for Sludge from Municipal Wastewater Treatment with references to Best Available Techniques (BAT). Fed. Environ. Agency Ger.
Wiechmann, B., Dienemann, C., Kabbe, C., Brandt, S., Vogel, I., Roskosch, A., 2013. Sewage sludge management in Germany. Umweltbundesamt, Bonn.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Anaerobtechnik und Energierückgewinnung (Vorlesung, 2 SWS)
Koch K [L], Koch K
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 7	**Total Hours:** 210	**Self-study Hours:** 150	**Contact Hours:** 60

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 sicentific paper, Cambridge University Press
• Glasman-Deal H (2009): Science Research Writing For Non-Native Speakers Of English: A Guide for Non-Native Speakers of English, Imperial College 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:
Advanced Seminar Circular Economy for a Sustainable Society: From Theory to Practice (Seminar, 4 SWS)
Fröhling M [L], Fröhling M, Heinrich V
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0246: Advanced Concepts and Methods in Urban Ecosystems | Advanced Concepts and Methods in Urban Ecosystems

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

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 pasing 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:
Barbosa, P. 2020. Urban ecology: its nature and challenges. CAB International, Boston, MA.
Brown, R. D. and Gillespie, T. J., 1995. Microclimatic Landscape Design: Creating Thermal Comfort and Energy Efficiency. John Wiley & Sons.
Carreiro, M M., Song, Yong-Chang and Wu, J. (eds.), (2008). Ecology, Planning and Management of Urban Forests. Springer: New York.
Craul, P. J., 1999. Urban Soils – Applications and Practices. John Wiley & Sons.
Ferrini, F., Konijnendijk van den Bosch, C., & Fini, A. (Eds.), (2017). Routledge handbook of urban forestry. London: Routledge.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Concepts and Methods in Urban Ecosystems (Übung, 3 SWS)
Egerer M [L], Egerer M, Pauleit S, Rahman M

Advanced Concepts and Methods in Urban Ecosystems (Seminar, 2 SWS)
Egerer M [L], Egerer M, Pauleit S, Rahman M

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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Hijazi, O; Munro, S; Zerhusen, B; Effenberger, M. (2016): Review of life cycle assessment for biogas production in Europe. Renewable and Sustainable Energy Reviews (54), 1291-1300.

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

WZ2726: Assessment of Sustainability in Agriculture - Theory and Case Studies | Assessment of Sustainability in Agriculture - Theory and Case Studies

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
The Assignment (Report+Assessment) is done as groupwork (2-3 students). As the report and assessment is based on a farm visit and to register presented details and understand the complexity of the system group working is necessary. The assignment shows the ability of the students to describe the farming system, to apply the developed criteria of sustainable agricultural practice, to assess the sustainability of farm as a system and to give recommendations for an improved development.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
Sustainability in farms context, principles of sustainability, criteria, inquiry strategies, indicator and indicator concepts, assessment and benchmarking.
Application to farming systems and farms at different level of intensification; case studies based on excursions: arable farming, organic vs. conventional farming, vegetable production in arable farms, grassland based farming system, dairy farming, suckling beef production.

Intended Learning Outcomes:
On successful completion of the module students are able to understand the idea of sustainability in the context of farms. They will have the ability to create criteria and indicators to assess sustainability of farms and to built up benchmarking systems. The students can describe farming

systems and are able to evaluate the sustainability using criteria and indicators and to document them in a report.

Teaching and Learning Methods:
Lectures with presentation of principles and systematics
Reading papers
Group work, mind mapping, meta plan technical to document discussion results.

Media:
Power Point, Flip Chart, Pin wall, Metaplan technic

Reading List:
Tba

Responsible for Module:
Dipl. Ing. Max Kainz; Dr. Hans-Jürgen Reents - Lehrstuhl für Ökologischen Landbau und Pflanzenbausysteme, Liesel Beckmann Str. 2, 85354 Freising, 08161/71 - 3778, kainz@wzw.tum.de, reents@wzw.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Assessment of Sustainability in Agriculture- Theory and Case Studies
Hans-Jürgen Reents, Max Kainz
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2736: Analytical Characterization of Soil Resources | Analytical Characterization of Soil Resources

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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)
Prietzel J, Schweizer S, Bucka F, Göttlein A, Kolb E, Laniewski R, Leemhuis S

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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 excercises. 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

WZ1308: Creation of a Life Cycle Assessment Study Using LCA Software | Creation of a Life Cycle Assessment Study Using LCA Software

Version of module description: Gültig ab summerterm 2020

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 120	**Contact Hours:** 3

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

Description of Examination Method:
The examination consists of an LCA report of around 20 pages which is the means to evaluate whether the students are able to create a life cycle assessment (LCA) using a special LCA software. After modelling of an own LCA case study the students write an LCA report based on a learning process and describe the used methodology for the life cycle assessment. The results of the LCA case study have to be analyzed and discussed in the report.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in Life Cycle Assessment, e.g. WZ4206 Material Flow Management and Application or WZ0156 Rohstoffmärkte, Ökobilanzierung, Waldzertifizierung (previous name Rohstoffmärkte und Qualitätssicherung), natural science (biology, chemistry, ecology, physics); understanding for agricultural and forestry production processes as well as for engineering science and social/cultural aspects.

Content:
The students acquire detailed and differentiated knowledge about the following topics:
- need of life cycle assessment
- procedure of life cycle assessment
- material and substance flow analysis including life cycle inventory
- life cycle impact assessment
- interpretation of LCA results
- development of strategies and measures for conducting and reporting of a life cycle assessment study

Intended Learning Outcomes:
By the means of the module the students are able to:
- define a system boundary and functional unit when creating a LCA study
- create processes and flows and how to link them in product systems using LCA software
- create a project with different scenarios and the relationships between different processes
- create their own processes and flows using primary data
- apply the assessment methods of indicator systems and life cycle assessment
- evaluate the project (using different LCIA methods)
- create an LCA Report individually

Teaching and Learning Methods:
Concerning teaching methods, lecture and presentation parts provide the extended theoretical foundation of conducting life cycle assessment. The OpenLCA software will be used for modelling and therefore installed on the students' laptop (optional) or they can work directly on a TUM-PC. LCA case studies in forestry and agricultural productions are introduced to the students and worked out in the class. A case LCA study will be examined systematically with the students with different scenarios. At the end, the students have to create their own LCA case study out of the forestry or agricultural field including the subsequent processing industries and to document all the steps done in a report including the methodology, results and discussion. The students are supervised by tutorials by the lecturers.

Media:
PowerPoint presentation, lecture sheets, case studies, OpenLCA software.

Reading List:
Klöpffer, W., Curran, M. (eds.). 2014 - 2017. LCA Compendium – The Complete World of Life Cycle Assessment. Book Series. Springer.
Klöpffer, W., Grahl, B. 2009. Ökobilanz (LCA): Ein Leitfaden für Ausbildung und Beruf. Wiley-VCH, Weinheim. 426 pp.
Brunner, P.H. Rechberger, H. 2016. Handbook of Material Flow Analysis: For Environmental, Resource, and Waste Engineers. Taylor & Francis Inc; 2. Revised Edition. 453 pp.
EC-JRC – European Commission - Joint Research Centre - Institute for Environment and Sustainability. 2010. International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union. 394 pp.
Baumann, H., Tillman, A.-M. 2004. The hitch hiker's guide to LCA an orientation in life cycle assessment methodology and application. Lund, Studentlitteratur.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Creation of a Life Cycle Assessment Study Using LCA Software (Seminar, 2 SWS)
Hijazi O [L], Hijazi O

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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 60	**Contact Hours:** 90

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:
Bréchet, T., & Eyckmans, J. (2009). Coalition theory and integrated assessment Modelling: Lessons for climate governance. Global Environmental Commons: Analytical and Political Challenges in Building Governance Mechanisms.
Rohling, M., & Ohndorf, M. (2012). Prices vs. quantities with fiscal cushioning. Resource and Energy Economics, 34(2), 169-187.
MacKenzie, I. A., & Ohndorf, M. (2012). Optimal monitoring of credit-based emissions trading under asymmetric information. Journal of regulatory economics, 42(2), 180-203.
Hake, J. F., Fischer, W., Venghaus, S., & Weckenbrock, C. (2015). The German Energiewende–history and status quo. Energy, 92, 532-546.
Climate Action Plan 2050 Principles and goals of the German government's climate policy. https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutzplan_2050_en_bf.pdf
EU ETS Handbook. https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf

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

Courses (Type of course, Weekly hours per semester), Instructor:
Climate Change Economics (WZ1590) (Vorlesung, 4 SWS)
Sauer J [L], Canessa C, Frick F
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 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
Due to Corona, the form of examination has changed as follows.
Assessment consisting of excercises. In a written test (Klausur, duration 60min, 60% of the module grade) 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.
In three graded exercises 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. The students prepare a video in groups including a role play of a panel discussion to develop their persuasive and critical skills as organizers and presenters, they become more familiar with political decision-making processes. The video is presented and discussed with all students participating. The grade for the seminar counts 40% of the module it consists of three equally weighted grades for each exercise.

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 divers 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:
IPCC (2013) Fifth Assessment Report of WGI, II, III. Houghton (2015) Global warming, the complete briefing. Most recent scientific literature.

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, Ghada W

Climate Change - The complete briefing (Vorlesung, 2 SWS)
Rammig A [L], Rammig A
For further information in this module, please click campus.tum.de or here.

Module Description

POL62200: Energy Transformation | Energy Transformation

Version of module description: Gültig ab winterterm 2017/18

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:
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 scienitific 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

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

Version of module description: Gültig ab summerterm 2017

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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.

Jaeger, W.K. (2005): Environmental Economics. Island Press.
Mankiw, N.G. and M.P. Taylor (2011): Microeconomics. 2nd Edition. South Western.
Perman, R., Y. Ma, J. McGilvray, M. Common (2003): Natural Resource and Environmental Economics. 3rd Edition. Pearson Education Limited.
Tietenberg, T. and L. Lewis (2010): Environmental Economics & Policy. Prentice Hall.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Environmental and Natural Resource Economics (WI000286) (Vorlesung mit integrierten Übungen, 4 SWS)
Glebe T
For further information in this module, please click campus.tum.de or here.

Module Description

WI001204: Economics of Water Use, Regulation and Markets | Economics of Water Use, Regulation and Markets

Version of module description: Gültig ab winterterm 2018/19

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Auffhammer, M. et al., "The Value of Supply Reliability in Urban Water Systems," Journal of the Association of Environmental and Resource Economists, Working paper.
Caswell, M. & D. Zilberman, "The Effects of Well Depth and Land Quality on the Choice of Irrigation Technology," American Journal of Agricultural Economics 68(1986): 798-811.
Chong, H. & D. Sunding, "Water Markets and Trading," Annual Review of Environment and Resources 31(2006): 239-264.

Gisser, M., “Groundwater: Focusing on the Real Issue,” Journal of Political Economy 91(1983): 1004-1027.
Green, G. et al., “Explaining Irrigation Technology Choices: A Microparameter Approach,” American Journal of Agricultural Economics 78(1996): 1064-1072.
Renwick, M. & R. Green, “Do Residential Demand Side Policies Measure Up? An Analysis of Eight California Water Agencies,” Journal of Environmental Economics and Management 40(2000): 37-55.
Zilberman, D. et al., “Changes in Water Allocation Mechanisms for California Agriculture,” Contemporary Economic Policy 12(1994): 122-133.

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:
Economics of Water Use, Regulation and Markets (WI001204) (Vorlesung, 4 SWS)
Sauer J [L], Vrachioli M
For further information in this module, please click campus.tum.de or here.

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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Precision Agriculture (Exercises) (Übung, 4 SWS)
Yu K
For further information in this module, please click campus.tum.de or 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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 quantiative 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:
Ardichvili, A., Cardozo, R., & Ray, S. (2003). A theory of entrepreneurial opportunity identification and development. Journal of Business Venturing, 18: 105–123.
Berti, G. and Mulligan, C. (2016). Competitiveness of Small Farms and Innovative Food Supply Chains: The Role of Food Hubs in Creating Sustainable Regional and Local Food Systems. Sustainability, 8 (616): 1-31.
Bolton, W.K. and Thompson, J.L. (2000). Entrepreneurs: Talent, Temperament, Technique. Butterworth Heinemann, Oxford.
Casson, M., (2003). The Entrepreneur, New York, NY: Edward Elgar Publishing.
Dunkelberg, et al. (2013). Do entrepreneurial goals matter? Resource allocation in new owner-managed firms. Journal of Business Venturing, 28: 225–240.
Grichnik, D. (2006). International Entrepreneurship: Entscheidungs- und Risikoverhalten von Unternehmensgründern und Venture-Finanziers in kulturellen Kontexten — Theoriebildung und empirische Analysen. Berlin: Duncker & Humblot-Verlag.
Howieson, et al. (2014). New Product Development in Small Food Enterprises. Journal of New Business Ideas & Trends, 12(1): 11 - 26.
Joakim, T. et al. (2016). Business model innovation in the agri-food sector: a literature review. British Food Journal, 118(6): 1462-1476.
Kim, W.C. and Mauborgne, R. (2005). Blue Ocean Strategy, Harvard Business School Press: Boston.

Shane, S. and Venkataraman, S. (2000). The Promise of Entrepreneurship as a Field of Research, Academy of Management Review, 25(1): 218–228.
McGrath, R. G. and MacMillan, I. (2000).The Entrepreneurial Mindset: Strategies for Continuously Creating Opportunity in an Age of Uncertainty.
Mirzaeia, O. et al. (2016). Product and Marketing Innovation in Farm-Based Businesses: The Role of Entrepreneurial Orientation and Market Orientation. International Food and Agribusiness Management Review, 19(2): 99-130.
Morris, et al. (2017): Farm diversification, entrepreneurship and technology adoption:Analysis of upland farmers in Wales. Journal of Rural Studies 53: 132-143.
Shadbolt, M.N. and Olubode-Awosola, F. (2016). Resilience, Risk and Entrepreneurship. International Food and Agribusiness Management Review, 19(2): 33-52 .
Sporleder, et al. (2008). Innovation in Food Products: First-mover Strategy and Entropy Metrics. International Food and Agribusiness Management Review, 11(3): 139-164.
York, G.J. and Venkataraman, S. (2010). The entrepreneur–environment nexus: Uncertainty, innovation, and allocation. Journal of Business Venturing, 25: 449–463.
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 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

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. 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 Engeneering 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)
Lichti F, 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 2020/21

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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

Description of Examination Method:
Aufgrund des Pandemiegeschehens hat der/die Studierende auch die Möglichkeit, an einer beaufsichtigten elektronischen schriftlichen Fernprüfung (Aufsicht mit Zoom, 180 min.) teilzunehmen (Onlineprüfung: WZ2732o). Diese Prüfung wird zeitgleich parallel in Präsenz angeboten (WZ2732).

Upon completion of the module, the students have a profound understanding of key aspects of environmental monitoringand 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, Krause A, Meyer B

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 Infrastrukturentwicklungen [FNQSI]

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** 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:
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:
Friedman, T. L. (2009). Hot, flat, and crowded: Why we need a green revolution--and how it can renew America
(Release 2.0, updated and expanded ; 1st Picador ed.). New York: Picador/Farrar, Straus and Giroux.
Heck, H.-D., & Meadows, D. L. (1972). Dennis Meadows [u.a.] Die Grenzen des Wachstums (The limits to growth,
dt.).
McDonough, W., & Braungart, M. (2002). Cradle to cradle: Remaking the way we make things (First edition). New
York: North Point Press.

Responsible for Module:
Prof. Dr.-Ing. Werner Lang sekretariat.enpb.bgu@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Fallstudien nachhaltiger Quartiers-, Stadt- und Infrastrukturentwicklungen (Seminar, 2 SWS)
Lang W [L], Hernández Chamorro A, Lang W, Schwering K, Theilig K

Nachhaltige Quartiers-, Stadt- und Infrastrukturentwicklungen (Vorlesung, 2 SWS)
Lang W [L], Hernández Chamorro A, Schwering K
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

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

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 asthe forest growth modelling part of the lecture can be presented best in a written formby 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:
FOREST GROWTH: Pretzsch, H., (2009): Forest Dynamics, Growth and Yield. Springer Verlag, Berlin, 664 S. 2009 published as Hardcover(ISBN 978-3-540-88306-7) 2010 published as paperback (ISBN 978-3-642-14861-3) FOREST OPERATIONS: Bowers, S. 2012. Designing woodland roads. Oregon State University. EC 1137. 21 pp. Dykstra, D. P. and Heinrich, R. 1996. FAO Model code of forest harvesting practice. 85 pp. Enters, D., Applegate, G.B., Kho, P. C.S., and Man, G. (Eds.) 2002. Applying reduced impact logging to advance sustainable forest management. FAO. Heinrich, R. Recent developments on environmentally friendly forest road construction and wood transportation in mountainous forests. Rummer, B. 2009. New technology in forest operations. www.forestlandowners.com. 3 pp. Sutherland, B.J. 2003. Preventing soil compaction and rutting in the boreal forest of western Canada. FERIC. 53 pp.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Low Impact Forest Operations (Vorlesung, 1,5 SWS)

Bauer E, Engler B

Low Impact Forest Operations Technology (Exkursion, ,5 SWS)
Bauer E, Engler B

Forest Growth (Vorlesung, 2 SWS)
Pretzsch H, Rötzer T
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 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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, 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:
Fengel, D.; Wegener, G. (2003): Wood - Chemistry, Ultrastructure, Reactions. Kessel Publishers
Dinwoodie, J.M. (2000): Timber: Its nature and behaviour. Van Nostrand Reinhold Publishers
Forest Products Laboratory (ed) (2010): Wood as an Engineering Material: http://www.fpl.fs.fed.us-documnts-FPLGTR-fplgtr.113-PL113.htm.
Rowell R. ed. (2012): Handbook of Wood Chemistry and Wood Composites. Sec. Edition, CRC Press Taylor & Francis Group, 703 pp.
Shmulsky, R., Jones P.D (2011): Forest Products & Wood Science, 6th ed. Wiley-Blackwell, Chichester UK

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:
Forestry Raw Materials and their Utilization (Vorlesung, 2 SWS)
Richter K, van de Kuilen J, Sanchez-Ferrer A

Forestry Raw Materials and their Utilization (Übung, 2 SWS)
Richter K, van de Kuilen J, Sanchez-Ferrer A
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
FAO (2018): State of the World's Forests; FAO (2016): Global Forest Resources Assessment 2015.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Forest Ecosystem Management (Vorlesung, 2 SWS)
Felbermeier B [L], Annighöfer P, Felbermeier B

Forest Management Planning (Übung, 3,5 SWS)
Knoke T, Bödeker K, Döllerer M, Gang B, Kienlein S, Pintado K
For further information in this module, please click 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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 (hygienie, 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 overexpoitation 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 excercise the students prepare a presentation in form of a broschure, 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
2. Helfman (2007) Fish Conservation: A guide to understanding and restoring global aquatic biodiversity and fishery
resources
3. Moyle & Cech (2004) Fishes An introduction to Ichtyology
4. Primack (2008) A primer of conservation biology

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], Bayerl H, 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

Module Level: Bachelor/Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 Linear Algebra
- 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 Analysis
- Walter Rudin, Real and Complex Analysis, McGraw-Hill Optimization

- 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
PDEs
- 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, Page Vizcaino J, Pekel E, Wollek A)
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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;
- U 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
- kexplain 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:
Frankham, et al. 2017, Genetic Management of Fragmented Animal and Plant Populations, Oxford University Press; Allendorf et al. 2013, Conservation and the Genetics of Populations, Wiley-Blackwell; Agrios, G.N. 2005, Plant Pathology, 5th edition. Elsevier Academic Press, Oxford; Speight, M.R. & Wylie, F.R., 2001: Insect pests in tropical forestry. CABI publishing; Ruppert, E.E. & Barnes, R.D., 1993: Invertebrate Zoology 6th edition (Chapter 16 insects; p 825-862)

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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Dessler, G. (latest edition). Human resource management, Prentice Hall: Upper Saddle River/NJ.

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, Wagner C
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Ahrends (2000) Meteorology today, 7th edition. Jones JAA (2010) Water Sustainability - A Global Perspective, Hodder Education London. Clarke R & King J (2004) The atlas of water. Figueres C. et al. (2003) Rethinking water management. Wescoat JL et al. (2003) Water for life, water management and environmental policy. Grambow M (2008) Wassermanagement.

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:
Management of Water Resources (Vorlesung, 2 SWS)
Estrella N, Menzel A

Introduction to Hydrometeorology (Vorlesung, 2 SWS)
Menzel A [L], Estrella N, Menzel A
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 135	**Contact Hours:** 45

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 develope 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 (identic 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 assistent, 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, Bazan S, Cadavid Isaza A, 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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 90	**Contact Hours:** 90

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 Bulleting (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).
• Jon Hovi & Tora Skodvin, eds. Climate Governance and the Paris Agreement. Special Issue, Politics and Governance, Open Access Journal, Vol. 4, No. 3 (2016).
• Falkner, R. (2013) Handbook of Global Climate and Environment Policy, Chichester: John Wiley & Sons Inc.
• David Coen, Julia Kreienkamp & Tom Pegram (2020) Global Climate Governance, Cambridge: Cambidge University Press.
• 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 | Introduction to Soil Science

Version of module description: Gültig ab summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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:
Brady, Weil: The nature and properties of soils, 14th edition, 2007.
Blume et al.: Scheffer/SchachtschabelSoilscience, 2016.
Eash, Sauer, O'Dell, Odoi, Bratz: Soil science simplified, 6th edition, 2016.
Blum, Schad, Nortcliff: Essentials of Soil Science, 2016.
FAO Guidelines for Soil Description. Prepared by Jahn, Blume, Asio, Spaargaren, Schad, 2006.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Soil Science: Lecture (Vorlesung, 2 SWS)
Schweizer S

Introduction to soil science: Field course (Übung, 3,5 SWS)
Wiesmeier M [L], Wiesmeier M, Garcia Franco N, Völkel J, Putzhammer S, Schad P
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2725: Land-Use Systems from Local and Global Perspectives | Land-Use Systems from Local and Global Perspectives

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 exam (duration: 30 minutes).
In this form of exam the students can show how they are able to explain the farming systems and describe the elements and farming methods. Due to a deeper discussion the examiner is able to evaluate the students under-standing of farm practices, system concepts and interactions with site conditions.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
Basic information on farming: crops, crop rotations, permanent crops: hops and orchards; soil management, weed management; implements and machinery; organic and mineral fertilizers; pesticide use; livestock: animal husbandry, breeding criteria; consumer expectations; exemplified by Bavarian and German cases.
Introduction to farming systems worldwide: pastoral systems, permanent crops plantation systems, mixed systems, arable systems, intensive animal keeping; horticultural systems; students experience with agricultural land use in their countries.

Intended Learning Outcomes:
On successful completion of the module students are able to remember and identify different crops, farm animals, machines and implements. They will be able to describe farming systems esp. the difference of organic and conventional systems. They will understand farm management methods and interactions inside farming systems. The students can classify land-use systems

worldwide and are able to explain the main elements and to evaluate the sustainability and resource impact.

Teaching and Learning Methods:
Lectures providing theoretical foundations. Examples will be given during the lectures.
Short field trips to farms and university research station, demonstrating crops, animals, technical equipment.
Short discussion sessions.

Media:
Power Point.

Reading List:
Tba

Responsible for Module:
Dr. Hans-Jürgen Reents; Dipl. Ing. Max Kainz - Lehrstuhl für Ökologischen Landbau und Pflanzenbausysteme Liesel Beckmann Str. 2, 85354 Freising, 08161/71 - 3778, reents@wzw.tum.de, kainz@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

WZ4094: Landscape Management - Application Study | Landscape Management - Application Study

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 95	**Contact Hours:** 75

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

Description of Examination Method:
The assessment is based on: 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:
TThe 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, Schneider T, Teixeira Pinto L
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 2020

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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:
IPCC (2013) Fifth Assessment Report; Shelton ML (2009): Hydroclimatology - Perspectives and Applications; IPCC (2008) Technical Paper VI on Climate Change and Water

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:
Introduction in Hydrological Modelling (Vorlesung, 2 SWS)
Chiogna G

Field Course in Applied Hydrometeorology (Vorlesung mit integrierten Übungen, 3 SWS)
Menzel A [L], Lüpke M, Menzel A
For further information in this module, please click campus.tum.de or here.

Module Description

WZ4206: Material Flow Management and Applications | Material Flow Management and Applications

Version of module description: Gültig ab winterterm 2018/19

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

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:
Brunner, P.H., Rechberger H. (2004): Practical Handbook in Material Flow Analysis. Advanced Methods in Resource and Waste Management. Lewis Publishers, Boca Raton, pp. 318.
Brunner, P.H.; Rechberger, H.; 2016: Handbook of Material Flow Analysis: For Environmental, Resource, and Waste Engineers. Taylor & Francis Inc; 2. Revised Edition, pp. 453
Weber-Blaschke, G.; 2009: Stoffstrommanagement als Instrument nachhaltiger Bewirtschaftung natürlicher und technischer Systeme. Ein kritischer Vergleich ausgewählter Beispiele. Schriftenreihe „Nachwachsende Rohstoffe in Forschung und Praxis“ des Wissenschaftszentrums Straubing, Bd. 1, Verlag Attenkofer, Straubing, 330 S.

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:
Material Flow Management and Application (Vorlesung, 3 SWS)
Weber-Blaschke G [L], Weber-Blaschke G
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

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 teached 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

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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Freeman, R.E (1984). Strategic Management: A stakeholder Approach. Boston.
Prell, C., K. Hubacek and M. Reed (2009). Stakeholder analysis and social network analysis in natural resource management. Society & Natural Resources 22(6): 501-518.
Chiffoleau, et al. (2014) Understanding local agri-food systems through advice network analysis. Agric Hum Values, 31:19–32
Lange, P. et al. (2015). Sustainability in Land Management: An Analysis of Stakeholder Perceptions in Rural Northern Germany. Sustainability, (7): 683-704.
Reed, M. S. et al. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management.Journal of Environmental Management 90(5): 1933-1949.

Mcadam, et al. (2016). Regional Horizontal Networks within the SME Agri-Food Sector: An Innovation and Social
Network Perspective. Regional Studies, 50(8): 1316–1329
Katz, N. et al. 2004. Network Theory and Small Groups. Small Group Research, 35(3): 307-332.
Sandström, A. and C. Rova (2010). Adaptive co-management networks: A comparative analysis of two fishery conservation areas in Sweden. Ecology and Society 15(3): 14.
Bixler, et al. R (2016). Network governance for large-scale natural resource conservation and the challenge of capture. Frontiers in Ecology and the Environment 14(3): 165-171.
Bixler, R. P. et al.(2016). Networks and landscapes: A framework for setting goals and evaluating performance at the large landscape scale. Frontiers in Ecology and the Environment, 14(3): 145-153.
Ernstson, et al. (2010). "Scale-crossing brokers and network governance of urban ecosystem services: The case of stockholm." Ecology and Society, 15(4): 28.
Muñoz-Erickson, T. A. and B. B. Cutts (2016). Structural dimensions of knowledge-action networks for sustainability. Current Opinion in Environmental Sustainability, 18: 56-64.
Wubben, E. and Gohar Isakhanyan. (2011). Stakeholder Analysis of Agroparks. Int. J. Food System Dynamics 2(2), 2011, 145#154.
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:
Network and stakeholder analysis: Sustainable resource use and agri-food system (Vorlesung, 4 SWS)
Abate Kassa G
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Haaren, C. v., Lovett, A. & C. Albert (2019): Landscape Planning with Ecosystem Services – Theories and Methods for Application in Europe. Springer Nature, Dordrecht. Additional material will be provided.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Landscape Planning - lecture (Vorlesung, 2 SWS)
Augenstein I

Landscape Planning - seminar (Seminar, 2 SWS)
Augenstein I
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

Module Level: Master	**Language:** German/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:
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:
Konstantin, Panos: Praxisbuch Energiewirtschaft - Energieumwandlung, -transport und -beschaffung, Übertragungsnetzausbau und Kernenergieausstieg, Springer Vieweg, Springer-Verlag GmbH Deutschland, eBook ISBN 978-3-662-49823-1, DOI 10.1007/978-3-662-49823-1, Hardcover ISBN 978-3-662-49822-4

Wagner, Ulrich; Heilek, Christian (Bearb.): Nutzung regenerativer Energien (Vorlesungsskript), 10., vollständig überarbeitete Auflage, Herrsching, E & M, Energie-&-Management-Verl.-Ges., 2009, ISBN: 978-3-9805179-3-5

The Power of Transformation - Wind, Sun and the Economics of Flexible Power Systems, International Energy Agency, OECD/IEA, 2014, France, ISBN: 978 92 64 20803 2

Hillier, Frederick S., Lieberman, Gerald J.: Introduction to operations research, New York, McGraw-Hill Education, 2015, ISBN: 978-0-07-352345-3, 0-07-352345-3, 978-0-07-126767-0, 978-1-259-25318-8, 1-259-25318-X

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

Courses (Type of course, Weekly hours per semester), Instructor:
Projektpraktikum Erneuerbare und Nachhaltige Energiesysteme (Forschungspraktikum, 4 SWS)
Hamacher T, Kuhn P, Breuning L, Cadavid Isaza A, de la Rua Lope C, Halilovic S, Kerekes A, Kleeberger H
For further information in this module, please click campus.tum.de or here.

Module Description

WI001205: People in Organizations: Managing Change and Sustainability in Agribusiness and the Food Industry | People in Organizations: Managing Change and Sustainability in Agribusiness and the Food Industry

Version of module description: Gültig ab winterterm 2018/19

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** 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:
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 agribusinsess 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
Brown, Donald R. (latest edition). An Experiential Approach to Organization Development, Prentice Hall: Boston.
Daft, Richard L. (latest edition). Organizational Theory and Design. South-Western/Cengage Learning.
Kreitner, Robert and Kinicki, Angelo (latest edition). Organizational Behavior. McGraw-Hill Irwin.
Morgan, Gareth 2006. Images of Organization. Updated ed., Sage: Thousand Oaks/CA.

Responsible for Module:
Vera Bitsch bitsch@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
People in Organizations: Managing Change and Sustainability in Agribusiness and Food Industry (WZ1563, WI001205) (Seminar, 4 SWS)
Bitsch V [L], Bitsch V, Huhn C, Wagner C
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 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
Aufgrund des Pandemiegeschehens wird die alternative Prüfungsform Klausur, schriftlich (90 min, WZ4082o) angeboten.

The learning outcomes are assessed by an oral examination. 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:
ABARE - JaakoPöyry (1999): Global Outlook for Plantations. Australian Bureau of Agricultural and Resource Economics (ABARE) Research Report 99.9, www.abare.gov.au. Evans, J., Turnbull, J. W. (2004): Plantation forestry in the tropics. FAO, (1998): FRA 2000 - Terms and definitions. Forest Resources Assessment Programme, Working Paper 1. FAO (2001): Global Forest Resources Assessment 2000. FAO Forestry Paper 140. Pandey, D. and Ball, J. (1998): The role of industrial plantations in future global fibre supplies. Unasylva 193, Vol. 49, 37 - 43. Sawyer, J., (1993): Plantations in the Tropics. Smith, D.M., Larson, B.C.,Kelty, M.J. and Ashton, P.M.S. (1997): The Practice of Silviculture: Applied Forest Ecology. Smith, J. (2002): Afforestation and reforestation in the clean development mechanism of the Kyoto protocol: implications for forests and forest people. Int. J. Global Environmental Issues 2 (3/4): 322-343. Shepherd, K.R. (1986): Plantation Silviculture. West, P. W. (2006): Growing Plantation Forests. Ashton, M.S. and Montagnini, F. (2000): The silvicultural Basis for Agroforestry Systems. Agroforesty: Principles and Practice: Special issue of Forest Ecology and Management, 45 (1991). Nair, P.K.R. (2012): Agroforestry, the future of global land use. Atangana et al. (2014): Tropical Agroforestry. Springer Verlag

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, Günter S

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 | Protected Areas Biodiversity and Management

Version of module description: Gültig ab summerterm 2020

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 word 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:
Jürgen Schultz (2005): The Ecozones of the World: Ecological Divisions of the Geosphere. Springer, Berlin. 459p.

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

Courses (Type of course, Weekly hours per semester), Instructor:
Protected Area Management (Vorlesung, 2 SWS)
Kühn R [L], Gula R, Rödl T

Biodiversity in Protected Areas (Vorlesung, 2 SWS)
Kühn R [L], Gula R, Rödl T
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

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, Westermayr M
For further information in this module, please click campus.tum.de or 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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 150	**Contact Hours:** 150

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 (Mokhtari A, Camenzind M)
For further information in this module, please click campus.tum.de or here.

Module Description

LS10007: Remediation of Contaminated Sites – Lecture and Seminar | Remediation of Contaminated Sites – Lecture and Seminar

Version of module description: Gültig ab summerterm 2022

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Remediation of Contaminated Sites - Regeneration of contaminated soils (Vorlesung, 2 SWS)
Bucka F

Remediation of Contaminated Sites – Investigation and remediation methods (Seminar, 2 SWS)
Heister K, Bucka F
For further information in this module, please click campus.tum.de or here.

Module Description

POL40100: Introductory Lecture: Politics and Technology | Ringvorlesung: Politics & Technology

Version of module description: Gültig ab summerterm 2020

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:
Current notice in view of the restricted presence operation due to the CoViD19 pandemic: If the general conditions (hygiene, distance rules, etc.) for a presence test are not available, the planned form of examination can be switched to electronic (remote) testing in accordance with §13a APSO. The decision about this change will be announced as soon as possible, but at the latest 14 days before the examination date by the examiner after consultation with the responsible examination board.

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 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)
Schreurs M (Mohammed N, 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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 6	**Total Hours:** 180	**Self-study Hours:** 135	**Contact Hours:** 45

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 or here.

Module Description

WZ1674: Research Methods and Economic Research Project | 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:
Hartford, Tim (latest edition). The Undercover Economist. Random House: New York.
O'Leary, Zina (latest edition). The Essential Guide to Doing Your Research Project. Sage: Los Angeles.
Committee on Science, Engineering, and Public Policy,
National Academy of Sciences, National Academy of
Engineering, and Institute of Medicine (latest edition). On Being a Scientist: A Guide to Responsible Conduct in Research.

Responsible for Module:
Vera Bitsch bitsch@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Research Methods and Economic Research Project (WZ1559, WZ1674) (Seminar, 4 SWS)
Bitsch V [L], Bitsch V, Carlson L, Wagner C
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 (Vorlesung, 4 SWS)
Wieland C [L], Wieland C
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 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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. 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:
The implementation of data interpretation and information extraction concepts and techniques is trained "hands on" with the help of advanced image processing and analysis programs. Topics: 1. Introduction to image processing concepts; 2. Implications of air- and space borne data takes; 3. Data types: Digital aerial photographs, high to very high resolution multispectral and hyperspectral scanner data, LIDAR data; 4. Development of interpretation keys; 5. Exercises on data pre-processing; 6. Unsupervised and supervised classification concepts, pixel-based, object based classification strategies; 7. Exercises on land use/land cover classification; 8. Basic verification concepts; 9. Exercises on the extraction of bio-geo-chemo-physical parameter from RS data; 10. Change detection concepts; 11. Interrelation of Remote Sensing with GIS; 12. Access and data download from geodata provider.

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:
The literature recommended within the Modules "Inventory Methods and GIS", "Remote Sensing and Image Processing", www.wiau.man.ac.uk/courses/cvmsc/Terminol.htm#SplitMerge;http://www.pfc.cfs.nrcan.gc.ca/landscape/inventory/wulder/large_area_rs/index.html; http://www.pfc.cfs.nrcan.gc.ca/landscape/inventory/wulder/hirespres.html; Uni Zürich, RSL: http://www.geo.unizh.ch/rsl2/; EARSeL: http://www-earsel.cma.fr/; http://www.ccrs.nrcan.gc.ca/ccrs/

eduref/tutorial/indexe.html; http://observe.ivv.nasa.gov/nasa/education/reference/main.html; http://rst.gsfc.nasa.gov/starthere.html

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, Schneider T
For further information in this module, please click campus.tum.de or here.

Module Description

BGU38031: Sanitation in the Global South | Sanitäre Versorgung im globalen Süden

Version of module description: Gültig ab winterterm 2018/19

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

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

Description of Examination Method:
The examination will be based on a final project report (60%) and presentation (40%).
For the final project, students will write a report on the case study area, a small town in northern India, applying content approaches learned during the class to create a holistic sanitation system for the town and evaluate its practical feasibility. Content and approaches include demonstrating (i) understanding the need for sanitation (based on health aspects and the Sustainable Development Goals), (ii) analysis and planning methods on sanitation projects (involving stakeholders and planning concepts such as CLUES and CLTS), (iii) creating sanitary system designs; and (iv) evaluating management and financing methods (taking into account classic and innovative financing methods). By additionally presenting the results of their final project, students demonstrate that they can explain their proposed design and ideas in a structured and understandable manner to a technical audience.
Each student’s grade will be determined by his/her individual contribution to the final project report and presentation, which will both be worked on in teams of 4 students. Particular emphasis will be placed on logical structure and the applicability of the design to the case study area in evaluating the final project reports and presentations.

Repeat Examination:

(Recommended) Prerequisites:
• Engineered Natural Treatment Systems
• Water and Wastewater Treatment Engineering
• Wastewater Treatment

Content:
• Identifying negative impacts of inadequate sanitation/motivation for good sanitation

• Identifying stakeholders and delineation of methods for behavioral change
• Developing an holistic engineered sanitation system
• Applying planning strategies, such as community led urban environment sanitation planning (CLUES) and community led total sanitation (CLTS)
• Stating concepts for financing sanitation projects
• Investigating and applying sanitation analysis and planning tools

Intended Learning Outcomes:
Upon completion of this project course students will be able to:
• Identify consequences of inadequate sanitation & describe the complexity and challenges of urban sanitation in various settlements (urban/peri-urban/rural)
• Summarize the Sustainable Development Goals (SDGs) and describe current international aid framework in the global context
• Identify stakeholders involved in successful sanitation planning and list different incentives for behavioral change
• Contrast different planning concepts such as CLUES and CLTS and apply those concepts on the case study area
• Apply urban sanitation analysis and planning tools to the case study focus area and develop case specific engineering solutions
• Distinguish between classical and innovative funding models

Teaching and Learning Methods:
This course is designed as an independent elective course. During the lecture, students will be primarily taught about social, technological and management aspects of successful sanitation projects in the Global South. Additional teaching support will be provided by external lecturers with professional experience in the international development field. Students will receive learning materials and literature to expand their knowledge, in addition to further information regarding the case study area. Project work will be conducted in teams of 4 students. Students will have the opportunity to discuss questions or approaches with the teaching team during weekly tutorial sessions focused on content taught in the class the same week, prior to submission of the final report. The results of the final report will then be presented to the teaching team.

Media:
ppt presentations

Reading List:
Gensch, R.; Jennings, A.; Renggli, S.; Reymond, P. Compendium of Sanitation Technologies in Emergencies; 2018.

United Nations Children Fund; World Health Organisation. Progress on Drinking Water, Sanitation and Hygiene; 2017.

Lüthi, C.; Morel, A.; Tilley, E.; Ulrich, L. Community-Led Urban Environmental Sanitation Planning (CLUES); Eawag-Sandec, WSSCC, UN-HABITAT, 2011.

Tilley, E.; Ulrich, L.; Lüthi, C.; Reymond, P.; Zurbrügg, C. Compendium of Sanitation Systems and Technologies; 2008.

Responsible for Module:
Uwe Hübner u.huebner@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

WI001165: Sustainable Entrepreneurship - Getting Started | Sustainable Entrepreneurship - Getting Started

Version of module description: Gültig ab summerterm 2017

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** 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:
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:
United Nations Sustainable Development Goals: http://www.un.org/sustainabledevelopment/sustainable-development-goals/
Business Model Canvas:
Osterwalder, A. & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. Wiley: New Jersey, US.

Responsible for Module:
Belz, Frank-Martin; Prof. Dr. oec.

Courses (Type of course, Weekly hours per semester), Instructor:
Sustainable Entrepreneurship - Getting Started (Life Scienes) (WI001165) (Limited places) (Seminar, 4 SWS)
Belz F [L], Rocchino R, Terveen N
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 | 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
Bouchery, Corbett, Fransoo, and Tan (2017): Sustainable Supply Chains: A Research-Based Textbook on Operations and Strategy. Springer: Berlin, Heidelberg, Germany.
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], Bitsch V, Carlson L, Huhn C, Wagner C
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2727: Sustainability of Food Chains | Sustainability of Food Chains

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
Combination of Poster and oral presentation provides to assess the students ability to conduct a life cycle analysis of a special food product. The poster needs a very concentrated presentation, focus on the important information and factors and shows the students capability to understand the principles of the LCA and the special food production process.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Attendance in Module 4209 and 4210 is recommended.

Content:
Food chains of processed food, from agricultural production via processing to packed product unit in a food store, principles of life cycle analysis, assessment criteria, energy input output ratio, energy efficiency, CO2 emission, carbon footprint, virtual water
LCA calculation and calculation program (Umberto).

Intended Learning Outcomes:
At the end of the module the students are able to understand food chains. They can describe and apply life cycle analysis to processed food products. They are able to assess energy and emission impact of different crop and animal production system and processing procedures. The will get basic skills of the software Umberto.

Teaching and Learning Methods:
Teachers Presentations Life cycle analysis, food chain, energy, CO2 emission and water impacts, students contributions, special aspects of processing paper reading for contributions to group discussions and outline of the final presentation.

Media:
Presentation notes, computer program.

Reading List:
Tba

Responsible for Module:
Dipl. Ing. Max Kainz - Lehrstuhl für Ökologischen Landbau und Pflanzenbausysteme Liesel Beckmann Str. 2, 85354 Freising, 08161/71 - 3034, kainz@wzw.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Sustainabilityof Food Chains
Max Kainz
For further information in this module, please click campus.tum.de or here.

Module Description

WZ2728: Sustainable Land-Use Management | Sustainable Land-Use Management

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
In a Power Point (or comparable tool) supported oral presentation the students can show, how they identify a special issue of farm management related to terms of sustainability. In the further outline of the presentation, the students will show how to discuss the topic based on recorded results from published papers, to explain conclusions and to suggestsolutions on improved sustainability.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
Agricultural systems and their relation to natural and human resources; site, economic and social conditions, regional and global,
adaptation of farm management techniques to principles of sustainability, research and scientific results, terms of politics and social debate, aims and scenarios for future development
Topics selected participative with the students.

Intended Learning Outcomes:
On successful completion of the module students are able to identify special problems of sustainability in farm management, economic and social conditions, to analyze the technical, social and economic impacts and to evaluate them on the background of criteria of sustainability. They will be able to create solutions for critical impacts.

Teaching and Learning Methods:
Lectures provide facts, background and theoretical foundations.

Papers have to be read and used in group work.
Group work.

Media:
Power Point Presentations
Flip Chart
Pin wall, Metaplan technique

Reading List:
Tba

Responsible for Module:
Dipl. Ing. Max Kainz; Dr. Hans-Jürgen Reents - Lehrstuhl für Ökologischen Landbau und Pflanzenbausysteme, Liesel Beckmann Str. 2, 85354 Freising, 08161/71 - 3778, kainz@wzw.tum.de, reents@wzw.tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Case Studies of Land-Use Management
Hans-Jürgen Reents, Max Kainz
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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 kaolinitc 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:
Blanco, H., Lal, R. (2008): Principles of soil conservation and management. Diamond, J. (1998): Guns, germs and steel. A short history of everybody for the last 13,000 years. Mirsal, I. (2008): Soil Pollution.

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

WZ2936: Sustainable and Environmental Regulations | Sustainable and Environmental Regulations

Version of module description: Gültig ab winterterm 2021/22

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Wintrobe, R. (2000): The Political Economy of Dictatorship, Cambridge University Press, Cambridge; Tremmel, J. (2006): Handbook of intergenerational justice, Edward Elgar, Cheltenham; Glasson, J., Therivel, R. & A. Chadwick (2019): Introduction to Environmental Impact Assessment. 5th edition. Routledge, London and New York: 394 pages; Sadler, B., Aschemann, R., Dusik, J, Fischer, T.B., Partidário, M.R. & R. Verheem (2011): Handbook of Strategic Environmental Assessment. Earthscan, London, Washington, DC. Additional material will be provided.

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

BGU70005: Transportation Economics | Transportökonomie [Transportation Economics]

Version of module description: Gültig ab winterterm 2017/18

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 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 (eg 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:
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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

• Pricing
• Freight Economics
• Sharing Economy

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 he supervision of a project work provide the quantitative methods for 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.

Media:
Presentation slides, whiteboard, readings

Reading List:
Small, Kenneth. Urban transportation economics. Vol. 4. Taylor & Francis, 2013.
Button, Kenneth. Transport economics. Edward Elgar Publishing, 2010.
Gómez-Ibáñez, José A., William B. Tye, and Clifford Winston, eds. Essays in transportation economics and policy: a handbook in honor of John R. Meyer. Brookings Institution Press, 2011.

Responsible for Module:
Antoniou, Constantinos; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Transportation Economics (Vorlesung mit integrierten Übungen, 4 SWS)
Antoniou C [L], Antoniou C, Ezzati Amini R, Rothfeld R
For further information in this module, please click campus.tum.de or here.

Module Description

BGU38033: Planning the Urban Water-Energy-Food Nexus | Urban Water-Energy-Food Nexus Planung

Version of module description: Gültig ab summerterm 2019

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 3	**Total Hours:** 90	**Self-study Hours:** 60	**Contact Hours:** 30

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 students, whereby an individual thematic focus will be defined for each student. The aim of the project is to prove understanding of basics of different technical and non-technical components of 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.

Repeat Examination:

(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

Teaching and Learning Methods:
The module will be taught as a lecture with seminar parts. It will explain major content in form of 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:
Presentations, group work

Reading List:
Hoff, H. (2011). Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm, pp. 52.
Gondhalekar, D. and T. Ramsauer (2017). Nexus City: operationalizing the urban Water-Energy-Food Nexus for climate change adaptation in Munich, Germany. Urban Climate 19: 28–40, DOI: 10.1016/j.uclim.2016.11.004 [OA]

Responsible for Module:
Daphne Keilmann-Gondhalekar

Courses (Type of course, Weekly hours per semester), Instructor:
Urban Water-Energy-Food Nexus Planung (Vorlesung, 2 SWS)
Keilmann-Gondhalekar D [L], Keilmann-Gondhalekar D
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 60	**Contact Hours:** 90

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 paramenters 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 or here.

Module Description

WZ1344: Urban Agriculture | Urban Agriculture

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
Edible Cities (Seminar, 2 SWS)
Egerer M

Urban Agriculture (Vorlesung, 2 SWS)
Egerer M [L], Egerer M
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 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 120	**Contact Hours:** 30

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. 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:
Oreopoulou V.; Russ W. (2007): Utilization of By-Products and Treatment of Waste in the Food Industry, Springer; New York.
Additional literature depending on themes.

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:
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

LS10006: Vertical Farming | Vertical Farming

Version of module description: Gültig ab winterterm 2021/22

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 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:
Project Vertical Farming (Projekt, 4 SWS)
Egerer M [L], Egerer M
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 summerterm 2021

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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

Description of Examination Method:
Aufgrund des Pandemiegeschehens wird die alternative Prüfungsform unbeaufsichtigte elektronische Fernprüfung
(90 min. Moodle-Upload, Online-Prüfung: WZ4201o) angeboten.

A written exam of 90 minutes 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 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, Statistics and GIS".
Basic knowledge of population biology, community and ecosystem ecology.

Content:
GIS:
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
9. Management measures for management plans

Vegetation Ecology:
1. Vegetation ecology: overview, historical notes and outline;
2. Vegetation and the environment: classification of natural & semi-natural vegetation;
3. Clonality in plant communities & seed ecology and assembly rules in plant communities;
4. Species interactions structuring plant communities;
5. Vegetation and the ecosystem & vegetation dynamics;
6. Plant functional types and traits & diversity and ecosystem function;
7. Vegetation conservation, management and restoration;
8. Plant invasions and invasibility of plant communities;
9. Vegetation mapping: vegetation types and scales, from landscape to regional;
10. Practical aspects of vegetation sampling and classification.

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
• Understand the basic principles for the study of plant communities
• Identify vegetation types and describe its main aspects
• Apply different methods of vegetation sampling and classification

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 fieldwork and presentation of proposals for landscape management measures.

Introduction of theoretical and methodological aspects related to vegetation ecology studies, classification of vegetation types and practical aspects regarding the discipline.

Media:
GIS Software, PowerPoint Presentations, Instruction videos.

Reading List:
Vegetation Ecology, 2nd edition (Edited by Eddy van der Maarel & Janet Franklin)
Vegetation Ecology of Central Europe, vol. I and II (by Christoph Leuschner & Heinz Ellenberg)
Global Vegetation – Fundamentals, Ecology and Distribution (by Jörg S. Pfadenhauer & Frank A. Klötzli)
The Ecology of Plants (by Jessica Gurevitch)
Vegetation Description and Data Analysis – A Practical Approach, 2nd edition (by Martin Kent)
From Plant Traits to Vegetation Structure – Chance and selection in the assembly of ecological communities (by Bill Shipley)
Data Analysis in Vegetation Ecology, 3rd edition (by Otto Wildi)

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

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

Vegetation Ecology (Vorlesung, 2 SWS)
Teixeira Pinto L
For further information in this module, please click campus.tum.de or here.

Module Description

WZ0322: Ecological Colloquium: Scientific Foundations and Applications in Practice | Ökologisches Kolloquium: Wissenschaftliche Grundlagen und Anwendungen in der Praxis [SciTravels]

Overview of current research topics from local to global

Version of module description: Gültig ab winterterm 2021/22

Module Level: Master	**Language:** German/English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

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:
Forum Naturschutz (Übung, 2 SWS)
Kollmann J

Weihenstephaner Kolloquium zur Angewandten Ökologie und Planung (Kolloquium, 2 SWS)
Kollmann J, Häberle K, Annighöfer P, Egerer M, Geist J, Grams T, Kögel-Knabner I, Leonhardt S, Menzel A, Pauleit S, Pretzsch H, Rammig A, Rötzer T, Schäfer H, Seidl R, Tellier A

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

Wissenschaftl. Reisen: von Beobachtungen und Grundlagen zur angewandten Forschung (Seminar, 2 SWS)
Leonhardt S [L], Annighöfer P, Egerer M, Leonhardt S

Wissenschaftl. Reisen: von Beobachtungen und Grundlagen zur angewandten Forschung (Übung, 1 SWS)
Leonhardt S [L], Annighöfer P, Egerer M, Leonhardt S
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

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 80	**Contact Hours:** 70

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:
FAO Guidelines for Soil Description. Prepared by Jahn, Blume, Asio, Spaargaren, Schad, 2006.
IUSS Working Group WRB: World Reference Base for Soil Resources 2014. Update 2015. 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:
World Soil Resources: Lecture (Vorlesung, 2 SWS)
Schad P

Bodenansprache und Bodenklassifikation nach internationalen Standards (Übung, 2,8 SWS)
Schad P
For further information in this module, please click campus.tum.de or here.

Module Description

WZ4198: Wildlife Management and Wildlife-Human Interactions | Wildlife Management and Wildlife-Human Interactions

Version of module description: Gültig ab winterterm 2015/16

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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:
This lecture combines contents of Wildlife Management and Wildlife Human Interactions. The key aspects are: 1) Principles of Wildlife Management & Wildlife Science, 2) Planning tools, 3) Case study: Strategic planning, 4) Conflicting views in WMT with case studies, 5) Basic Concepts in Ecology, 6) Reintroductions studies, 7) Global threats to Conservation, 8) Nature of human dimensions (HD) from a research perspective through various examples 9) Nature of various wildlife-human interactions from different perspectives, 10) Nature of public involvement and HD as an applied approach 11) Types of conflict, levels of planning and how to work with people toward solutions, 12) Understanding decision-making processes.

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:
Sinclair et al. 2006, Wildlife Ecology, Conservation, and Management, ISBN 1-4051-0737-5 ; Krausman 2002, Wildlife Management, ISBN 0-1328-0850-1; Pullin 2002, Conservation Biology, ISBN 0-521-64482-8

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

Courses (Type of course, Weekly hours per semester), Instructor:
Wildlife-Human Interactions (Seminar, 2 SWS)
Kühn R [L], Bath A

Wildlife Management (Vorlesung, 2 SWS)
Kühn R [L], Rödl T
For further information in this module, please click campus.tum.de or here.

Module Description

WZ4207: Waste and Waste Water Treatment | Waste and Waste Water Treatment

Version of module description: Gültig ab winterterm 2020/21

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 90	**Contact Hours:** 60

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. Asses 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:
Bilitewski, B., Härdtle, G., Marek, K.; Weissbach, A.; Boedekker, A.: Waste Management, Springer-Verlag Berlin Heidelberg, ISBN-10: 9783642082122

Waste Management: https://issuu.com/tkverlag/docs/waste_management_4
Evans, G. (Ed): Biowaste and Biological Waste Treatment, ISBN: 978-1-902916-08-8

Wastewater Treatment:
la Cour Jansen, J., Arvin, E., Henze, M., Harremoes, P., 2019. Wastewater treatment - Biological and chemical Processes. Polyteknisk Boghandel og Forlag, Lyngby.
Tchobanoglous, G., Burton, F.L., Tsuchihashi, R., Stensel, H.D., 2013. Wastewater Engineering: Treatment and Resource Recovery. McGraw-Hill, Boston.
Wiechmann, B., Dienemann, C., Kabbe, C., Brandt, S., Vogel, I., Roskosch, A., 2013. Sewage sludge management in Germany. Umweltbundesamt, Bonn.

Responsible for Module:
Konrad Koch

Courses (Type of course, Weekly hours per semester), Instructor:
Waste Management (Vorlesung, 2 SWS)
Franke M

Waste Water Treatment (Vorlesung, 2 SWS)
Koch K
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 summerterm 2020

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 75	**Contact Hours:** 75

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 Biodiversty, 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.

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 Bankiing
3. Factors affecting terrestrial and aquatic Biodiversty
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 Biodiverstiy of terrestial 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 excercise " 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 excercise, 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 excercise
material: lecture notes, flip-chart/board, plus different materials for methodological/technical training

Reading List:
1. Primack (2014) Essentials of Conservation Biology 2. Frankham (2010) Introduction to Conservation Genetics 3. Sutherland (2009) Conservation Science and Action

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

Courses (Type of course, Weekly hours per semester), Instructor:
Conservation Biology and Applied Genetics (Vorlesung, 2 SWS)
Kühn R

Case Studies in Nature Conservation (Übung, 3 SWS)
Kühn R, Stoeckle B
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 summerterm 2015

Module Level: Master	**Language:** English	**Duration:**	**Frequency:** winter semester
Credits:* 10	**Total Hours:** 300	**Self-study Hours:** 300	**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 internship, the student has to hand in an internship report and a certification letter where the employer verifies the duration with eventual miss-outs and the kind of work which was performed from the trainee.

Repeat Examination:

(Recommended) Prerequisites:
None

Content:
According to the study rules for the Master Program "Sustainable Resource Management", every student has to serve an internship outside his/her home country with a minimum duration of 7 weeks (10 ECTS credits). The internship should act as a possibility for the trainee to get insight into the different areas of operation for sustainable resource managers. The student should be enabled to survey his individual career aspirations and to contact potential employers. The student has to search for an internship by his/her own and it has to be scheduled in a way that it does not conflict with the lecture periods. A recommended time spell for the internship is between the second and third semester (August October). The internship can be split into two parts with a minimum duration of one month each. Further divisions are possible just due to significant reasons, but have to be approved in advance by the internship advisor. It is possible to serve the internship in different organisations; however the minimum duration of one month must be kept. The internship must take place outside a university. Recommended are organisations that are potential employers. The program coordinator and the internship advisor can give guidance regarding choices of possible organisations.

Intended Learning Outcomes:
On successful completion of the module, students are able to apply their theoretical knowledge in a practical environment. Furthermore, they are able to incorporate themselves into new companies and to analyze and assess business organizations.

Teaching and Learning Methods:

Media:

Reading List:

Responsible for Module:
Friederike Dörr – Praktikantenamt Weihenstephan – www.praktikantenamt-weihenstephan.de Alte Akademie 1, 85354 Freising, 08161 / 71-3710, friederike.doerr@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 2016/17

Module Level: Master	**Language:** English	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 30	**Total Hours:** 900	**Self-study Hours:** 890	**Contact Hours:** 10

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 including the starting Master's Thesis Proposal. 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 Master Thesis is the closure project of the program on which students have the opportunity to show their availability to work independently and adapt to a problem in a limited period of time. 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 - which is really important - 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 the faculty, 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 Program. To officially register the master’s thesis, students have to hand in the application form for the master’s thesis in the program coordination office The form has to be completed together with the tutor. After this registration the student has a timeframe of six months to finish the master’s thesis.

Intended Learning Outcomes:
After finishing the module the students have the availability to work independently and adapt to a problem in a limited period of time. Additionally, they are able to draw conclusions from the data they found and to present and discuss their results in an appropriate way.

Teaching and Learning Methods:
Learning activities: literature search, scientific reading, to solve problems, to practice, to design an experiment, to create a scientific proposal and a scientific thesis, to constructive critique their own work and to revise it on basis of feedback, all parts under time constraints. Therefore, the learning methods are: an introduction lecture 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:
General information: Dr. Eva Bauer (Program Coordinator) Studienfakultät Forstwissenschaft und Ressourcenmanagement, Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, 08161/71-4464; srm@wzw.tum.de;

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.

Requirement Proof of Proficiency in German | Nachweis Deutschkenntnisse

Module Description

WZ8000: Accredited Requirement Proof of Proficiency in German | Anerkennung Nachweis Deutschkenntnisse

Version of module description: Gültig ab summerterm 2018

Module Level:	Language:	Duration:	Frequency:
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**

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

Description of Examination Method:

Repeat Examination:

(Recommended) Prerequisites:

Content:

Intended Learning Outcomes:

Teaching and Learning Methods:

Media:

Reading List:

Responsible for Module:

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

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

Module Description

SZ03011: Intensive Course German as a Foreign Language A1.1 | Blockkurs Deutsch als Fremdsprache A1.1

Version of module description: Gültig ab summerterm 2010

Module Level: Bachelor/Master	**Language:** Language taught	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

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

Description of Examination Method:
1 final written exam 90 min. (100%) - no learning aids permitted
The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam.
Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing. Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
none

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as shopping, going to a restaurant, public transport etc.
Students learn and practice basic vocabulary on topics such as family, occupation, leisure time, food and living, plural noun forms, personal and demonstrative pronouns and simple forms of negation. They become familiar with numbers, prices and time, learn how to ask and answer simple questions about a person or family, as well as talk about matters of everyday life in simply structured sentences in the simple present.
Students learn different strategies for effective, self-motivated, independent learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A1 of GER.
Upon completion of this module, students are able to express themselves using everyday expressions and simple sentences. They are able to introduce themselves and other people, they can ask and answer simple questions about personal details, describe daily routines in a simple manner and provide information about themselves in writing in simple sentences.
Furthermore, students are able to communicate their wishes, if dialog partners are willing to help and to speak slowly and clearly.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia teaching and learning materials (chalk/white board, overheads, worksheets, images, films, etc.) and online resources

Reading List:
Textbook (to be announced in class)

Responsible for Module:

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

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

Module Description

SZ03021: Intensive Course German as a Foreign Language A1.2 | Blockkurs Deutsch als Fremdsprache A1.2

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** Language taught	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

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

Description of Examination Method:
1 final written exam 90 min. (100%) - no learning aids permitted
The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam.
Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing. Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
Firm knowledge of level A1.1; placement test with the achievement A1.2

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as shopping, going to a restaurant, public transport etc.
Students learn and practice basic vocabulary on topics such as family, occupation, leisure time, food and living. They learn to talk about matters of everyday life in simply structured sentences in the tenses simple present and present perfect simple and practice the usage of modal verbs, the imperative and the two-case preposition.
Students learn different strategies for effective, self-motivated, independent learning. They acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A1 of GER.
Upon completion of this module, students are able to express themselves using everyday expressions and simple sentences.
Students are able to answer simple questions about themselves and their family and pose questions, in kind, to a dialog partner. They are able to arrange meetings and provide information about themselves in writing. They are able to describe daily routines in the past and present tense and can successfully communicate their wishes in everyday situations, such as going shopping or eating in a restaurant, with dialog partners who are willing to help and speak slowly and clearly.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

Reading List:
Textbook (to be announced in class)

Responsible for Module:

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

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

Module Description

SZ03031: Intensive Course German as a Foreign Language A2.1 | Blockkurs Deutsch als Fremdsprache A2.1

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

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

Description of Examination Method:
1 final exam 90 min. (100%) - no learning aids permitted
The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam. Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing.
Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
Firm knowledge of level A1.2; placement test with the achievement A2.1

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as traveling, at the doctor’s office, searching for an apartment, in a department store, among colleagues, friends or neighbors.

Students learn and practice basic vocabulary and expressions on topics such as education, profession, health and traveling. Students learn and practice using simply structured main and subordinate clauses (that, because, and, than, etc.), employing the preterit (modal verbs) and perfect, as well as the comparative, the superlative and the declination of the adjective. They reinforce and expand the usage of the prepositions in the accusative and dative case.

Students learn strategies for successful verbal and written communication despite minimal language skills. Opportunities will be made available for effective, self-motivated, independent learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A2 of GER.
Upon completion of this module, students are able to understand and use simple sentences and expressions in conversations on a broad spectrum of familiar topics. These conversations are based on basic information concerning everyday life and subjects relevant to studying or working, including sociocultural aspects of German-speaking countries.
For example, students are able to describe themselves and other people, their living situation, state of health, leisure time activities and job situation.
Students are able to understand longer texts and letters about familiar topics that include foreseeable information and are written in simple language about everyday life or job related topics. Students are able to compose short, informative texts or notifications about basic situations in everyday life or situations related to studying.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

Reading List:
to be announced in the Class

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Blockkurs Deutsch als Fremdsprache A2.1 (Seminar, 4 SWS)
Gemaljevic J, Kretschmann A, Niebisch D, Semeraro G
For further information in this module, please click campus.tum.de or here.

Module Description

SZ03051: Intensive Course German as a Foreign Language B1.1 | Blockkurs Deutsch als Fremdsprache B1.1

Version of module description: Gültig ab winterterm 2015/16

Module Level: Bachelor/Master	**Language:** German	**Duration:** one semester	**Frequency:** winter/summer semester
Credits:* 4	**Total Hours:** 120	**Self-study Hours:** 60	**Contact Hours:** 60

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

Description of Examination Method:
1 schriftlicher End Term Test 90 min. (100%) - keine Hilfsmittel erlaubt
In der schriftlichen Prüfung werden die in der Modulbeschreibung angegebenen Lernergebnisse geprüft. Sie beinhaltet Fragen zur Anwendung von Wortschatz und Grammatik, zu Text- bzw. Leseverstehen, sowie Aufgaben zur freien Textproduktion. Das Hörverstehen wird anhand von Hörbeispielen mit Hörverstehens-Fragen überprüft, die schriftlich beantwortet werden müssen. Mündliche Reaktionsfähigkeiten werden anhand der Anwendung entsprechender Redemittel in schriftlichen Dialogbeispielen überprüft.

Repeat Examination:

(Recommended) Prerequisites:
Sound knowledge of level A2.2; placement test level B1.1

Content:
In this module, knowledge of German as a foreign language will be further developed, enabling students to express themselves in German independently and confidently in familiar situations, e.g. in the classroom, at work, in free time and with the family, on topics of general interest, e.g. films, music, sports, etc, when standard German is spoken. Students expand and test a basic repertoire of logical main and subordinate clauses (final clauses, consecutive clauses, relative clauses), learn and practice the use of reflexive verbs, the function and use of second subjunctive and the passive. They review and develop elementary aspects of grammar, such as the use of the tenses and prepositions. They examine specific cultural features with regard to festivals and traditions, the educational system, the business world, lifestyles and leisure activities, and obtain insight into contemporary culture in Germany.

Intended Learning Outcomes:
The module is aimed at level B1 of the CEFR. Students acquire knowledge of German as a foreign language at the standard language level with a focus on intercultural, cultural and academic aspects. Students obtain team competence through collaborative work in mixed, multinational groups. Following completion of this module, students can make themselves understood in most situations which occur in the context of studies, career and leisure time in German speaking regions. They can report on academic and business careers; express hopes and wishes; make, accept or reject invitations; give advice and directions; express and discuss opinions. They can understand and summarize the general content of simple, authentic texts from the everyday world and take part in spontaneous discussions on familiar topics. Students can compose longer personal letters and texts on personal experiences.

Teaching and Learning Methods:
The module consists of a seminar in which course objectives will be achieved in an activity-oriented, communicative atmosphere through listening, reading, writing and speaking exercises in individual, partner and group work. The fundamental language skills conveyed in the classroom are reinforced through the use of guided self-learning in the form of prepared (and online) materials.

Media:
Textbook; multimedia teaching and learning materials (chalk/white board, overheads, worksheets, images, films, etc.) and online resources.

Reading List:
Textbook (to be announced in class)

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Blockkurs Deutsch als Fremdsprache B1.1 (Seminar, 4 SWS)
Niebisch D, Oelmayer J, Schimmack B, Stoephasius J
For further information in this module, please click campus.tum.de or here.

Module Description

SZ0303: German as a Foreign Language A2.1 | Deutsch als Fremdsprache A2.1

Version of module description: Gültig ab winterterm 2019/20

Module Level: Bachelor/Master	**Language:** German	**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:
1 final exam 90 min. (100%) - no learning aids permitted
The midterm exam is intended to monitor students' learning progress and reduce the amount of material covered in the final exam. Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing.
Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
Firm knowledge of level A1.2; placement test with the achievement A2.1

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as traveling, at the doctor’s office, searching for an apartment, in a department store, among colleagues, friends or neighbors.

Students learn and practice basic vocabulary and expressions on topics such as education, profession, health and traveling. Students learn and practice using simply structured main and subordinate clauses (that, because, and, than, etc.), employing the preterit (modal verbs) and perfect, as well as the comparative, the superlative and the declination of the adjective. They reinforce and expand the usage of the prepositions in the accusative and dative case.

Students learn strategies for successful verbal and written communication despite minimal language skills. Opportunities will be made available for effective, self-motivated, independent learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A2 of GER.
Upon completion of this module, students are able to understand and use simple sentences and expressions in conversations on a broad spectrum of familiar topics. These conversations are based on basic information concerning everyday life and subjects relevant to studying or working, including sociocultural aspects of German-speaking countries.
For example, students are able to describe themselves and other people, their living situation, state of health, leisure time activities and job situation.
Students are able to understand longer texts and letters about familiar topics that include foreseeable information and are written in simple language about everyday life or job related topics. Students are able to compose short, informative texts or notifications about basic situations in everyday life or situations related to studying.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Deutsch als Fremdsprache A2.1 (Seminar, 4 SWS)
Aßmann J, Bauer G, Comparato G, Geishauser C, Gemaljevic J, Keza I, Kovacs O, Kutschker T, Nierhoff-King B, Schlüter J, Semeraro G
For further information in this module, please click campus.tum.de or here.

Module Description

SZ0304: German as a Foreign Language A2.2 | Deutsch als Fremdsprache A2.2

Version of module description: Gültig ab winterterm 2019/20

Module Level: Bachelor/Master	**Language:** German	**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:
1 final exam 90 min. (100%) - no learning aids permitted
Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing.
Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
Firm knowledge of level A2.1; placement test with the achievement A2.2

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as traveling, at the doctor’s office, searching for an apartment, in a department store, among colleagues, friends or neighbors.
Students reinforce and augment basic vocabulary and expressions on topics such as education, profession, living and traveling. Students learn and practice classifying and using an extended spectrum of main and subordinate clauses (final clause, indirect questions, temporal subordinate clause, causal sentence). They also learn to employ the preterit (modals verbs) and perfect and will repeat and expand the usage of the prepositions and the declination of the adjective.
Students learn strategies for successful verbal and written communication despite minimal language skills. Opportunities will be made available for effective, self-motivated, independent

learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A2 of GER.
Upon completion of this module, students are able to understand and use simple sentences and expressions in conversations on a broad spectrum of familiar topics. These conversations are based on basic information concerning everyday life and subjects relevant to studying or working, including sociocultural aspects of German-speaking countries.
For example, students are able to describe themselves and other people, their living situation, state of health, leisure time activities and job situation. Students are able to communicate in various situations, for example, when searching for an apartment, traveling or on holiday, and are able to report about their experiences in simple standard language.
Students are able to understand longer texts and letters about familiar topics that include foreseeable information and are written in simple language about everyday life or job related topics. Students are able to compose short, informative texts or notifications about basic situations in everyday life or situations related to studying.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:
Deutsch als Fremdsprache A2.2 (Seminar, 4 SWS)
Aßmann J, Bauer G, Comparato G, Feistle C, Hagner V, Hanke C, Kostial M, Reulein C, Schimmack B, Selent D, Stiebeler H, Thiessen E
For further information in this module, please click campus.tum.de or here.

Module Description

SZ0322: German as a Foreign Language A2.1 plus A2.2 | Deutsch als Fremdsprache A2.1 plus A2.2

Version of module description: Gültig ab winterterm 2019/20

Module Level:	Language: German	Duration: one semester	Frequency: winter/summer semester
Credits:* 8	Total Hours: 240	Self-study Hours: 150	Contact Hours: 90

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

Description of Examination Method:
1 final exam 90 min. (100%) - no learning aids permitted
Written exams will assess students level of acquisition of the learning outcomes specified in the module description. Specifically, exam questions focus on the usage of vocabulary and grammar, as well as reading comprehension and text production. Listening comprehension is tested by posing questions based on audio samples to which students respond in writing.
Verbal skills are evaluated using appropriate prompts from sample print dialogs.

Repeat Examination:

(Recommended) Prerequisites:
Firm knowledge of level A1.2; placement test with the achievement A2.1

Content:
In this module, students acquire basic knowledge of the German language, including intercultural and regional aspects, that will enable them to express themselves in everyday situations, such as traveling, at the doctor’s office, searching for an apartment, in a department store, among colleagues, friends or neighbors.
Students learn and practice basic vocabulary and expressions on topics such as education, profession, health and traveling. They learn and practice classifying and using an extended spectrum of main and subordinate clauses (final clause, indirect questions, temporal subordinate clause, causal sentence). They learn to employ the preterit (modal verbs) and perfect, how to use the comparative and the superlative, as well as the declination of the adjective (in the nominative, accusative and dative case). They also reinforce and expand the usage of prepositions in the accusative and dative case.

Students learn strategies for successful verbal and written communication despite minimal language skills. Opportunities will be made available for effective, self-motivated, independent learning. Students acquire teamwork skills through collaborative work in multinational mixed groups.

Intended Learning Outcomes:
The module is based on level A2 of GER.
Upon completion of this module, students are able to understand and use simple sentences and expressions in conversations on a broad spectrum of familiar topics. These conversations are based on basic information concerning everyday life and subjects relevant to studying or working, including sociocultural aspects of German-speaking countries.
For example, students are able to describe themselves and other people, their living situation, state of health, leisure time activities and job situation. Students are able to communicate in various situations, for example, when searching for an apartment, traveling or on holiday, and are able to report about their experiences in simple standard language.
Students are able to understand longer texts and letters about familiar topics that include foreseeable information and are written in simple language about everyday life or job related topics. Students have the ability to compose short, informative texts or notifications about basic situations in everyday life or situations related to studying.

Teaching and Learning Methods:
The module consists of a seminar covering material appropriate to desired learning outcomes and encompassing relevant listening, reading, writing and speaking exercises. These exercises may take the form of individual, partner or group work, implementing a communicative and activity-oriented approach. Students have the opportunity to deepen basic knowledge conveyed in the seminar through independent study and work, using specified (online) materials covering fundamental grammar and communication patterns of the foreign language.
Voluntary homework (preparation and follow-up work) reinforces classroom and structured learning.

Media:
Textbook; multimedia-based teaching and learning materials (black board, overheads, exercise sheets, image, film, etc.) also online

Reading List:

Responsible for Module:

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

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

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