

# Degree Program Documentation

## Master's Program Sustainable Resource Management

Part A

TUM School of Life Sciences

Technical University of Munich

## General Information:

- Administrative responsibility: TUM School of Life Sciences
- Name of degree program: Sustainable Resource Management
- Degree: Master of Science (M.Sc.)
- Standard duration of study and credits: 4 semesters of enrollment and 120 credit points (CP)
- Form of study: Full time
- Admission: Aptitude assessment (EV - Master's)
- Start: Winter semester 2020/2021
- Language of instruction: English
- Main location: Campus Weihenstephan (Freising)
- Academic administrator (program design): Prof. Dr. Klaus Richter
- Contact for further questions (regarding this document): Team Quality Management  
[qm.co@ls.tum.de](mailto:qm.co@ls.tum.de)
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# 1 Degree Program Objectives

## 1.1 Purpose of the Degree Program

The international, English-language master's program "Sustainable Resource Management" is an interdisciplinary and transdisciplinary program that prepares students from all over the world and from a wide range of disciplines for the diverse challenges of sustainable resource management.

Natural resources such as soil, water, air and biodiversity form the essential basis of human life and economic activity. They serve as sources of food, raw materials and energy, as living and recreational space, or as means to reduce pollutant emissions. Their consumption is increasing rapidly worldwide. Global trends such as population and economic growth will further increase this consumption. This results in serious environmental problems such as loss of biodiversity, soil degradation, water shortages and air pollution. In addition, competing uses and conflicts of interest are increasingly developing around the ever scarcer resources. This is increasingly leading to political tensions at both national and international level.

These ecological and political developments make it essential to manage natural resources sustainably while simultaneously taking into account social, ecological and economic aspects. A consistently sustainable and intelligently controlled resource management is the chance to increase the socio-political room for scope of action again. Management, from Latin *manus* (hand) and *agere* (to lead), refers in the course of study to correspondingly targeted, effective and reflexive human actions with regard to management, organization, planning, communication, evaluation and strategic development in terms of socially responsible use, utilization and provision of resources as well as resource sinks. Challenges of sustainable resource management are characterized by a lack of oversight, complexity, high conflict potentials, many actors, and the absence of universal action orientations. This requires that graduates must have multilayered competences in order to be able to make decisions in the sense of a management of natural resource consumption. Graduates are active both in the development of solutions in the field of natural resource problems and in the moderation between different interest groups and their different approaches to solutions. This requires not only a profound knowledge of the various natural resources, but also a comprehensive understanding of the system as well as extensive planning and methodological skills. The international master's program "Sustainable Resource Management" provides the necessary basis for this. The focus is on learning suitable management methods for solving problems. In addition, the professional and personal development of the students is the focus of the program.

## 1.2 Strategic Significance of the Program

The teaching of sustainable thinking is the central point of the mission approach of the Faculty of Forestry and Resource Management. The faculty's goal is to impart to the students a modern image of sustainability based on the four pillars of ecology, socio-economics, production and culture. This strategic goal of the faculty is also an essential content of the three degree programs offered by the faculty. It is one of the objectives of the Bachelor's program "Forest Science and Resource Management" as well as of the two Master's programs "Forestry and Wood Science" and "Sustainable Resource Management". In the international degree program "Sustainable Resource Management", sustainable management is taught across a broad spectrum of resources.

As a life science program, the master's program "Sustainable Resource Management" fits seamlessly into the School of Life Sciences (SoLS), for which health, sustainability, the environment and land use have been defined as key themes. The program contributes significantly to raising the profile of the SoLS in the area of sustainable management and action. This sustainable way of thinking and acting also supports the mission statement of the Technical University of Munich (TUM), which sees itself as a servant of society with responsibility for future generations. Another goal of TUM is to increase the global networking of society, science and technology. With its international orientation and students from all over the world, the master's program "Sustainable Resource Management" makes a significant contribution to this and also helps to promote cosmopolitanism and cultural tolerance.

## 2 Qualification Profile

With a focus on sustainable management of natural resources, the international master's program "Sustainable Resource Management" teaches students the principles of sustainable management and action from different dimensions of the concept of sustainability. Across all disciplines and management competencies, students have internalized the key competencies of sustainable action and are able to make decisions based on these in terms of sustainable resource management.

Upon completion of the Master's degree program, graduates will be able to independently use various analytical tools and technologies, conduct environmental analyses, or create and assess land use plans. On the basis of the corresponding subject-specific competences with regard to the natural resources dealt with in the degree program, they will be able to understand, analyze and evaluate information from the complex scientific methods and tools and to use it in their work in a targeted manner for the conception of sustainable resource use plans. The graduates are contact persons for e.g. analysts, environmental protection groups, companies, political representatives or stakeholders in civil society and are able to understand their respective professional discourses, research methods and results and evaluate these in the context of sustainability.

Depending on the elective modules offered from a total of eight "Science Topics" in the degree program, students have extended expertise in the areas of management and protection of forest ecosystems, wildlife management and management of protected areas, landscape management, renewable energies, climatology, material and waste management, agricultural land use and soil science. Students have the opportunity to further deepen their competences in the "Science Topics" by selecting focused modules from individual areas of interest.

Following Wiek's sustainability competences, strategic, anticipatory as well as normative and interpersonal competences are taught in addition to holistic, interdisciplinary thinking. Systemic competences include holistic, interdisciplinary thinking and skills to combine ecological, social and economic sustainability and to independently create own concepts to reconcile the different interests. Furthermore, anticipatory competences enable graduates to design scenarios, develop visions and deal with risk and uncertainty. The graduates are able to collect sustainability values and to orientate themselves using different learned cooperation concepts. Their change management skills allow them to develop innovative solutions. They are able to define specific goals of sustainable resource management against the background of different expectations and interests and to develop suitable management strategies in cooperation with stakeholders.

Furthermore, they can constructively accompany the practical implementation, evaluate the results and critically question the success. Graduates are enabled to make data-supported decisions as key actors and decision-makers in questions of sustainable resource management and to deal with conflicts. Interpersonal and communicative competences play a central role in the moderation of conflicts. These competences include skills in presentation, dialogue and scientific discussion. In addition, the graduates of the program possess a high degree of social and intercultural competence, which they can use internationally as the basis for successful conflict management, as well as a sound knowledge of foreign languages. Students are encouraged to work efficiently and goal-oriented, both independently and in teams, and to assume responsibility in projects. In addition to the professional education, the program promotes the students' personal competencies, which enable the graduates to act on a civic, political and cultural level.

Graduates are able to independently plan, conduct, manage and evaluate subject-related research projects in accordance with applicable scientific standards. Research results can be presented using appropriate methods and graduates have a scientific self-image and professionalism and can critically assess their scientific skills. This enables graduates to analyze and evaluate subject-specific discourses and positions in order to make them practically usable for sustainable resource management in cooperation with experts, researchers and laypersons and to develop and implement management strategies from them.

## **3 Target Groups**

### **3.1 Target Audience**

The master's program "Sustainable Resource Management" is aimed at nationally and internationally qualified graduates with a scientific-technical or socio-scientific background who want to expand and deepen their competences in the field of sustainable resource management. The program is also aimed explicitly at students who already have professional experience.

### **3.2 Program Prerequisites**

In addition to knowledge from the fields of engineering, natural sciences, economics and social sciences, a very good command of the English language is a particular prerequisite. In this respect, students should be able to present scientific and technical problems in a precise and goal-oriented manner.

Also required is a great and varied interest in the subject-specific areas and the will to deal intensively with the relevant issues in courses, internships and the preparation of the Master's thesis. It is also essential that students are prepared to participate in subject-specific excursions and exercises (some of which last several days).

Students should be able to think in a networked and analytical way and have a basis for a method-oriented and scientific way of working. They should have a well-founded systems thinking and be able to apply their theoretical basic knowledge to concrete problems. An independent and solution-

oriented way of working, both individually and in a team, is also an advantage. Good communication and presentation skills are also advantageous. A basic information competence with regard to scientific publications is required.

### 3.3 Target Numbers

The number of students enrolled in the courses offered by the Faculty of Forest Science and Resource Management has risen continuously in recent years, which indicates the popularity of the topics covered (see Fig. 1, black line). This is particularly true of the international master's program in Sustainable Resource Management, which was introduced in the winter semester of 2001/02. The number of first-time enrollments increased rapidly after the introduction of the program and has ranged between 80 and 125 students in recent years (see Fig. 1, blue bar). Overall, the number of students in the Sustainable Resource Management program is increasing (see Fig. 1, blue line), and this trend is very much appreciated in the context of the increasing importance of the topics covered in the program with regard to current global ecological and political developments.

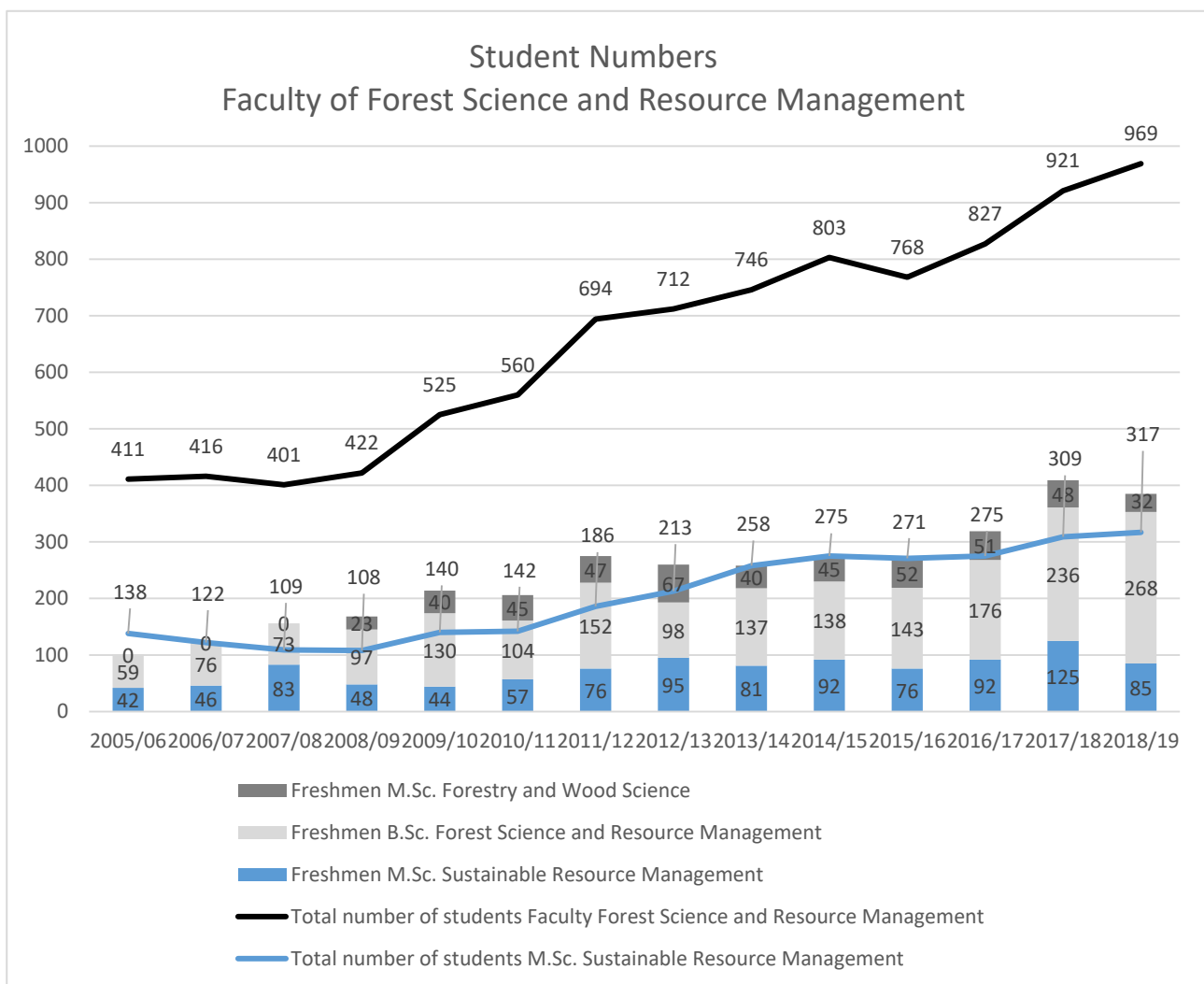


Fig. 1: Student numbers Faculty of Forest Science and Resource Management

The attractiveness of the program is also reflected in the initial sharp rise in applicant numbers, which have now settled at a consistently high level (cf. fig.2). The decline in applicant numbers for the 2018/19 winter semester can be attributed to several circumstances. Among them is the uncertainty of international applicants regarding the proof of German language proficiency introduced throughout Bavaria in 2018, as well as changes in the application process for international applicants with the application tool "Uni Assist". This decrease was already compensated in the following application period 2019/20.

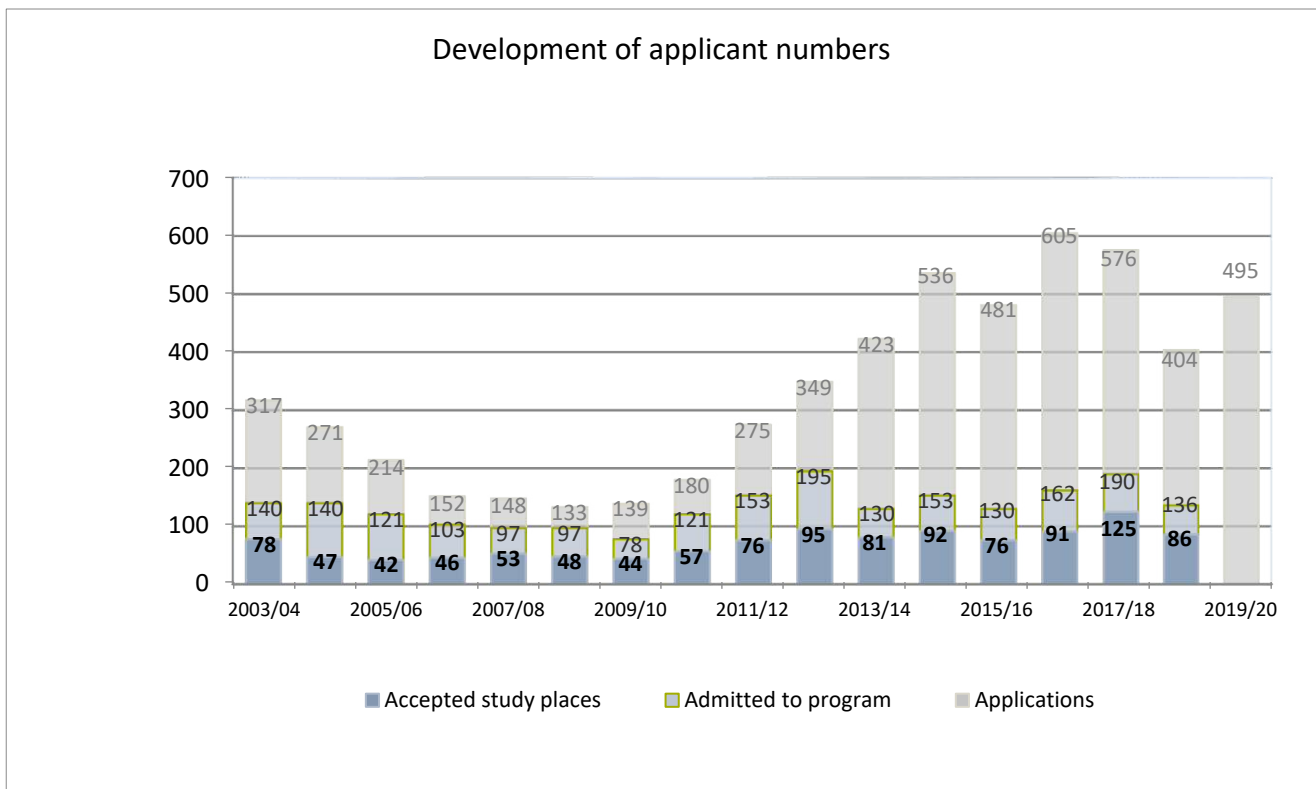


Fig. 2: Development of student numbers „Sustainable Resource Management“



The international character of the program can be seen in its global topics and their relevance, as well as in the English language of instruction, and in the proportion of international students, which has always averaged around 70% in recent years. The international students show a high diversity in their countries of origin. On average, 42 different countries are represented in the study program "Sustainable Resource Management". In the 2018/19 cohort, the 80 first-year students came from 26 different countries around the world (see Figure 3).

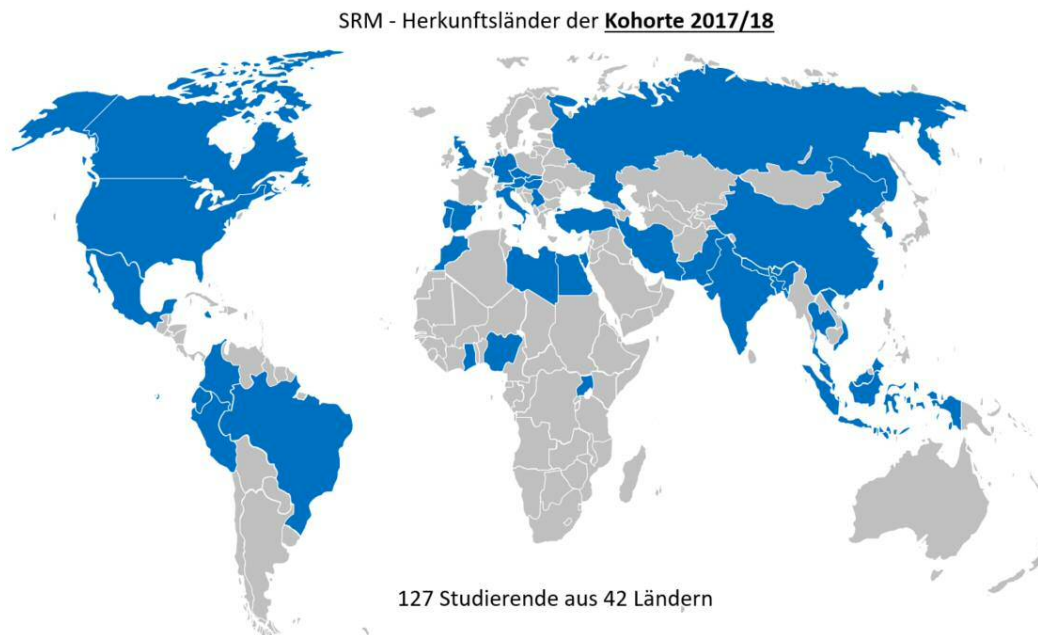


Fig. 3: World map with countries of origin cohort 17/18

## 4 Demand Analysis

The increasing global demand and consumption of natural resources represents one of the greatest ecological and political challenges of the 21<sup>st</sup> century due to the shortage of sources and the lack of renewability. In addition, the progressive pollution of soils, air and water resources poses a major threat to sustainable global development due to increasing pollutant emissions and a lack of education or deliberate ignorance. These factors are also reflected in the labor market, which increasingly requires employees in the field of environmental protection, renewable energies or ecosystem management. The field of sustainability management is becoming increasingly important due to current global developments. For some years now, sustainability managers have been responsible in all larger companies and organizations for the integrative consideration and implementation of social, ecological and economic concerns (sustainability controlling). Hence, this is an attractive field of employment for graduates of the master's program "Sustainable Resource Management". Current developments such as climate change promote the frame conditions for the profession of resource manager more than ever, and the current economic and environmental situation contributes to a growing demand for qualified personnel in the field of sustainable resource management and environmental protection. More than 6.3% of all employees in Germany worked in the field of environmental protection in 2014. Since 2002, environmental protection employment has steadily increased and around 2.7 million people work for environmental protection in Germany. Between 2010 and 2012 alone, the number of people working in environmental protection increased by 12.5%, equaling 245,000 people. The development of the number of employees shows that environmental protection is an important factor for the labor market. The labor market in the field of environmental protection includes not only jobs in the classic environmental protection areas, but also the upstream stages of the value chain and is therefore also highly relevant for the field of activity of resource management. Other sectors of the economy, such as vehicle manufacturing, the chemical industry and agriculture, are also linked to the fields of activity of environmental protection and resource management by ecological trends. An increase in employment can be seen especially in the field of environmental protection-oriented services. As shown in Figure 3, this is the largest sector of the environmental protection industry, with approximately 1.38 million people employed.

## Erwerbstätige im Umweltschutz 2012

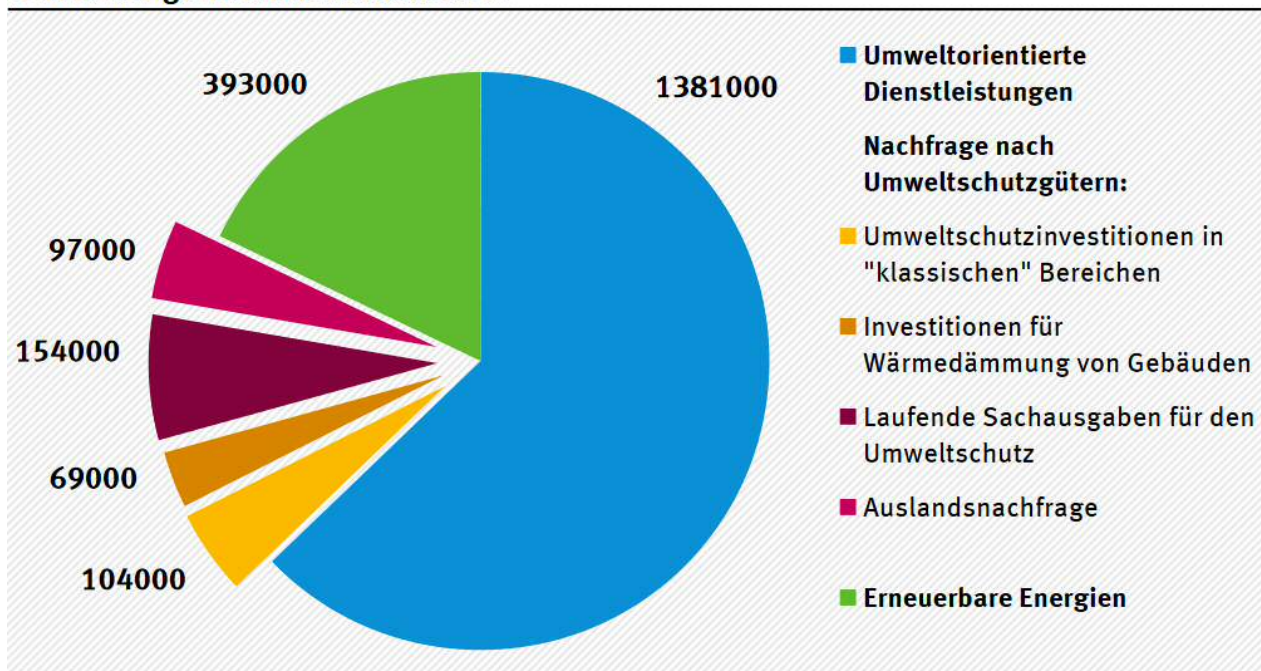


Figure 4: Employees in environmental protection in 2012, Federal Environment Agency (2016): Employment in environmental protection - development and overall economic significance. In Umweltbundesamt (Hrsg.): Umwelt, Innovation, Beschäftigung – updated 2016 edition. p. 5.

Blue: Environment-oriented services; yellow: Environmental protection investments in "classic" areas; orange: Investments for thermal insulation of buildings; dark red: Current non-personnel expenses for environmental protection; red: Foreign demand; green: Renewable energies.

Environmentally oriented services cover a very broad spectrum. This also includes fields of activity for graduates of the "Sustainable Resource Management" degree program. Environmentally oriented services include, for example, services for companies, including environmentally oriented databases and information systems, environmentally oriented legal and business advice, architectural and engineering offices, technical, physical and chemical investigations. Public services, e.g. environmental legislation at various levels of local authorities, environmental consulting, environmental planning as well as control, testing and measuring activities also fall within the employment spectrum of graduates. The same applies to services in the field of environmental education and other public and private services such as non-governmental organizations or mobility services, including marketing, research, mediation, information, consulting and transportation related to a more efficient and environmentally compatible use of the transport system. Environmentally oriented financial and insurance services such as financing of environmental protection projects or regulation and financing of environmental damage also fall into the sector of environmentally oriented services.

In addition to the growing sector of the environmental protection industry on a national level and the associated positive career prospects for graduates of the "Sustainable Resource Management" program, there is also an increasing demand for employees who have a high level of international experience, foreign language skills and intercultural competence. Fields of activity in the context of sustainable resource management include management activities in national and international governmental and non-governmental organizations (NGOs), environmental consulting and environmental information, ecosystem protection and management, environmental assessment and certification,

as well as science and education. Graduate surveys show that graduates of the Sustainable Resource Management program are active in the relevant fields, with NGOs and universities playing a particularly important role as employers. In view of social and political developments, employees will be needed in the future who can act as guides for the future in times of political uncertainty and ecological challenges and who can make professionally sound decisions.

## 5 Competition Analysis

### 5.1 External Competition Analysis

The external competition analysis shows that both nationally and internationally, several universities offer Master's programs in the field of natural resource management, which are indirectly in competition with the master's program "Sustainable Resource Management" at the Technical University of Munich due to their orientation. This makes it clear that the universities are responding to an increased demand for graduates in this field. The master's program "Sustainable Resource Management" at the TU Munich stands out from its external competitors due to the following characteristics:

- The program has been recognized as an official project of the United Nations World Decade 2005-2014 "Education for Sustainable Development" for the years 2006/2007 and 2013/14. This international award is given by the United Nations in cooperation with UNESCO to high-quality and innovative initiatives for teaching sustainable thinking and action and underlines the high quality of the program.
- The Faculty of Forestry has its own forestry operation near Landshut, which is managed by the Institute of Forest Management, for carrying out exercises and practical courses. This makes it possible, in vicinity to the Weihenstephan campus, to deepen and expand the theoretical content of the degree program together with the students on concrete objects.
- The program involves a large number of external lecturers from Germany and abroad, which gives students the opportunity to acquire skills in all areas of resource management and to establish contacts outside the university. In addition, these experts from various disciplines often have many years of experience in international cooperation and can pass this on directly to the students. Students also benefit from the large number of international projects and contacts of the various chairs and departments of the academic faculty.
- The high proportion of international students (approx. 75%) as well as the English teaching language contribute decisively to the special characteristics and atmosphere of the degree program. On the one hand, this promotes the intercultural competence of all students and teachers and, on the other hand, significantly enriches the teaching by integrating a wide variety of individual professional backgrounds and experiences. In addition, students have the opportunity to network worldwide beyond their studies, which is supported by the faculty through an active alumni network.
- To promote sustainable resource management, the Audi Foundation for the Environment established the "SRM Award" for outstanding Master's theses in 2010. The award emphasizes the importance of the degree program for the economy.

At the international level, there are a large number of Master's programs related to sustainable resource management, which makes a competitive analysis difficult. In the following, selected English-language Master's degree programs at national and international level are listed and compared on the basis of their focus.

Table 1: External competitive analysis Sustainable Resource Management

University	Degree program	Focus/Qualification Objectives
HU Berlin	Integrated Natural Resource Management (INRM)	Theoretical and methodological knowledge, analytical concepts and applicable skills in the field of management and conservation of natural resources. Students develop a basic understanding of the interaction of natural and social systems as well as sustainable use of resource systems recognizing their potential vulnerability and protection requirements. The curriculum is based on the comprehensive expertise gathered at the Albrecht Daniel Thaer Institute of Agricultural and Horticultural Sciences in the Faculty of Life Science. It integrates knowledge from different academic fields both in natural sciences, including ecological systems and production techniques, and social sciences such as economics, political sciences, institutional and organizational analysis, which are all relevant to the understanding and improvement of natural resource management.
TU Bergakademie Freiberg	Sustainable and Innovative Natural Resource Management - SINReM	Innovative and sustainable production, recovery and management of primary and secondary resources. The curriculum includes mining, exploration and extraction processes to recovery and recycling technologies (e.g. clean technology, CO <sub>2</sub> -neutral recovery of resources from waste water and waste streams). The thematic scope covered by SINReM also combines scientific-technological fields with economic, environmental and entrepreneurial aspects. Technological feasibility, sustainability and circular economy receive great attention in the holistic teaching and learning processes.
TH Köln	Natural Resources Management and Development	Management of natural resources systems, Natural resources economics and governance, Project and business management, International cooperation and development
Bergische Universität Wuppertal	Sustainability Management	International Corporate Governance, International Economics, Advanced OR-methods in Operations Management, Nachhaltige Energieversorgung, International Environmental Economics & International Policy Issue

Christian-Albrechts Universität Kiel	Sustainability, Society and the Environment	Analytical concepts of Economy and Social Sciences, Society, Development and Governance, Sustainability Economics, Environmental Management, Coastal Systems
Christian-Albrechts Universität Kiel	Environmental Management	System analysis and modeling, Geographic Information Systems (GIS), data management and analysis, training of adapted management procedures with regard to economic and social aspects
BTU Cottbus-Senftenberg	Environmental and Resource Management	Environmental Sciences, Environmental Engineering, Environmental Management
ESCP Europe	International Sustainability Management	Sustainability culture and business ethics, supply chain, CSR and CSR reporting, environmental management and marketing, climate change, economic theory
Hochschule Eberswalde	Global Change Management	Proactive Sustainable Use of Natural Resources, Global Change and Development, Natural Resource Management in Transformation Countries, Advanced Ecosynomics & Global Leadership
Hochschule Pforzheim	Life Cycle & Sustainability	Methodological expertise in Life Cycle Assessment (LCA), production and product-related material and energy flow analyses, sustainability management and corporate social responsibility, energy systems and lean production
Hochschule Rhein-Waal	Sustainable Development Management	Globalization and Sustainable Development, Development Economics and Policy, International Law and Compliance, Management of Development Projects, Macroeconomics
Hochschule Trier	Sustainable Change	Three pillars "Ecology and Technology", "Economy", "Sociology, Politics and Ethics" and "Studium Generale", basics of sustainability from various perspectives, climate and energy, resources
Leuphana Universität Lüneburg	Sustainability Management	Sustainable Development, Corporate Social Responsibility (CSR), Sustainability Marketing, Accounting & Sustainability Measurement, Entrepreneurship & Innovation
Leuphana Universität Lüneburg	Global Sustainability Science	Implementation of sustainable development strategies, international, inter- and transdisciplinary, and research-oriented orientation
Ernst Moritz Arndt Universität Greifswald	Landscape Ecology and Nature Conservation (LENC)	Climate change, vegetation ecology, aquatic ecology, conservation, environmental ethics, ornithology, landscape ecology, land use, restoration ecology
Albert-Ludwigs-Universität Freiburg	Environmental Sciences	Land use and nature conservation, environmental modeling and GIS, wildlife management and biodiversity, climate change, renewable resources, bioenergy

Albert-Ludwigs-Universität Freiburg	Environmental Governance	Environmental law, sustainable development, environmental policy, environmental economics, environmental management, environmental ethics, environmental sociology
Universität für Bodenkultur Wien	Natural Resources Management and Ecological Engineering	Strong international focus and based on cooperation between the Lincoln University in Canterbury, New Zealand, the Czech University of Life Sciences Prague and the University of Natural Resources and Life Sciences, Vienna
TU Hamburg-Harburg, Universitat Autònoma de Barcelona, Universidade de Aveiro, Aveiro, Aalborg Universitet, Kopenhagen	Joint European Master in Environmental Studies (JEMES)	Environmental engineering, environmental management, wastewater management, renewable energies, environmental assessment, social sciences
Universität Trier	Environmental Sciences	Environmental monitoring, pollutant assessment, applied remote sensing, modeling, environmental protection, environmental management, mass transport
Universität Hohenheim	Environmental Science - Soil, Water and Biodiversity (Double Degree)	Climate change, water and soil management, environmental impacts, land use, ecosystem management, biodiversity, environmental management
Lunds Universitet, Schweden	Environmental Studies and Sustainability Science	Sustainable development: focus on energy, transportation, engineering, water; environmental science, environmental management, landscape development
Wageningen University, Wageningen, Niederlande	Environmental Sciences	Aquatic ecology, environmental economics, environmental policy, environmental systems analysis, water and soil management, environmental education, meteorology, environmental technology, environmental toxicology
Tel Aviv University, The Porter School of Environmental Studies, Tel Aviv, Israel	Environmental Studies	Environmental ecology, climate change, water management, environmental law, Marine Ecology, Environmental Policy, Sustainable Development, Energy Policy, Globalization

## 5.2 Internal Competition Analysis

The TU Munich offers related degree programs with different orientations to the master's program "Sustainable Resource Management". These include, for example, the international degree program "Environmental Engineering" at the TUM School of Engineering and Design, which provides students with advanced knowledge and methods in a combination of two specific areas of specialization. Here, various relevant disciplines of the TUM School of Engineering and Design are combined. Out of 11 areas of specialization, two are chosen. The following areas of specialization are available for selection:

1. Urban Water Engineering
2. Water Resources Management
3. Hydraulic Engineering
4. Hydrogeology, Groundwater, Geothermal Energy
5. Modelling and Measurement of Flow and Transport
6. Resource Efficiency in Urban Planning
7. Environmental Geotechnics
8. Environmental Hazards and Risk
9. Sustainable Urban Mobility Planning
10. Transportation Engineering and Control
11. Water-Food-Energy Nexus

The focus of the program is on an engineering education, which enables the students to derive engineering tasks and technical solutions in the field of environmental engineering.

The existing Master's degree program "Renewable Resources" is also one of the related courses, whose language of instruction is German, unlike "Sustainable Resource Management". The focus of the course is on the utilization of renewable raw materials in terms of economic efficiency. The interdisciplinary master's program in Renewable Resources, offered jointly by the Technical University of Munich and the Weihenstephan-Triesdorf University of Applied Sciences, covers the entire value chain of renewable resources up to the marketing and sale of products made from renewable resources. Economic issues and ecological aspects of the cultivation and use of renewable raw materials are dealt with. Students have the opportunity to specialize in one of the following four areas of study during their studies:

1. Cultivation systems of renewable raw materials
2. Chemical and material use of renewable raw materials
3. Energetic use of renewable raw materials
4. Economy of renewable raw materials

Also the two Master's programs "Forestry and Wood Science" and "Ecological Engineering" are related to the English-language "Sustainable Resource Management". The focus of the master's program in Ecological Engineering is on the development of land use concepts and the management of competitive situations between different land use concepts. The master's program "Forestry and



Wood Science" focuses on forests as complex ecosystems. The management of these ecosystems requires not only a sound knowledge of the forest ecosystem but also a comprehensive understanding of the system on a scientific basis. In the course of study, the entire value chain is covered, from production in the forest to the finished wood product. The scientific foundations of forestry play just as important a role as the technical utilization and marketing of forestry products and the social significance of the forest.

The unique feature of the master's program "Sustainable Resource Management" is its holistic and global approach. The focus here is on the management of natural resources such as water, air, soil and biodiversity with a view to sustainable development. Furthermore, the program unites students from many different nations and is a unique program due to its internationality and the commitment of its student body and faculty.

## 6 Program Structure

In total, the master's program "Sustainable Resource Management" comprises 120 CP in four semesters including an eight-week professional internship and the master's thesis. Each semester comprises 30 credits according to ECTS, which are earned in module courses. As an international program, the language of instruction and examination in the master's program "Sustainable Resource Management" is English. The following figure provides an overview of the structure of the program:

International Master of Science Program (MSc) in Sustainable Resource Management 1 Semester = 30 Credits (CP)				
4 SoSe 30 CP	Master's Thesis 30 CP			
3 WiSe 30 CP	Elective Modules from Science Topics 30 CP	Elective Module 5 CP	GES 3 CP	Internship 12 CP
2 SoSe 30 CP		Elective Module 5 CP	Elective Module (auf Antrag) 5CP	
1 WiSe 30 CP	Management Aspects 10 CP	Sustainability and Nature Science Aspects 10 CP	Inventory Methods, Statistics and GIS 6 CP	Scientific Communication 4 CP

Fig. 6: Curriculum Sustainable Resource Management

The first semester is divided into the obligatory areas "Management Aspects", "Sustainability and Nature Science Aspects", "Inventory Methods, Statistics and GIS" and "Scientific Communication". The modules that have to be completed in the subject areas are compulsory modules, which form a basis for the freedom of choice from the 2nd semester onwards. In total, after the first semester, students must attend 45 CP in the elective area according to their personal focus of interest, 30 CP of which are in the area of Science Topics. In addition, there is a further selection of elective modules that are not assigned to a Science Topic. To the extent of 3 CP, students have the opportunity to sign up for interdisciplinary competencies in the "General Education Subject". The internship comprises 8 weeks and equates 12 CP. The final master thesis comprises a total of 30 CP.

## 6.1 1<sup>st</sup> Semester (Required Modules)

The degree program "Sustainable Resource Management" is characterized by a high degree of internationality as well as heterogeneity in the previous education of the first-year students. In order to create a common professional basis and to make it easier for international students to start and plan their studies, the first semester of the program consists of compulsory basic modules with a total of 30 CP. The compulsory modules are divided into the areas "Management Aspects", "Sustainability and Nature Science Aspects", "Inventory Methods, Statistics and GIS" and "Scientific Communication".

10 CP must be completed in the area "Management Aspects", as well as 10 CP in the area "Sustainability and Nature Science Aspects". In the area "Management Aspects" the students have the possibility to choose 10 CP out of 15 offered CP, i.e. they take 2 out of 3 modules freely combinable. The area "Sustainability and Nature Science Aspects" consists of two modules with 5 CP each. "Inventory Methods, Statistics and GIS" and "Scientific Communication" form two modules with 6 and 4 CP each (see Fig.7).

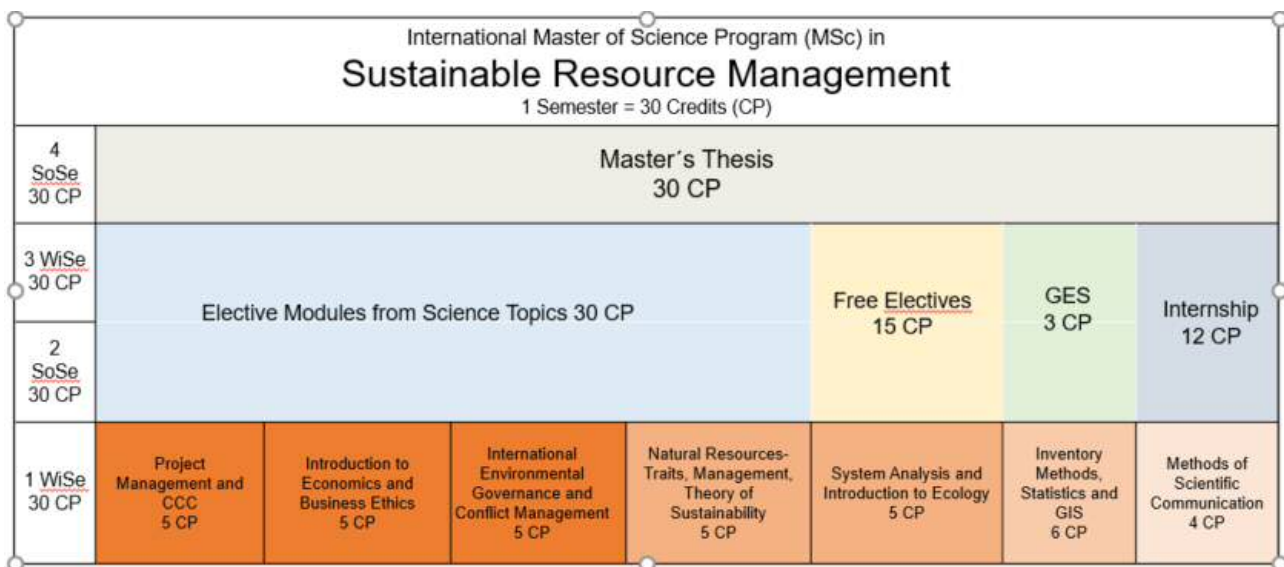


Fig. 7: Curriculum + 1<sup>st</sup> Semester

## 6.2 Management Aspects

- The modules offered in the compulsory area "Management Aspects" represent an important core area of the degree program. Students select 10 CP from a range of 15 CP here. The following modules are offered in the first semester:
- Project Management, Public Relations and Cross Cultural Communication (5 CP)
- Introduction to Economics and Business Ethics (5 CP)
- International Environmental Governance and Conflict Management (5 CP)

Students learn to plan and manage natural resources, their provision, use, processing and organization in a sustainable manner. While the controversies and uncertainties regarding the guiding concept of sustainability are addressed and discussed in the course itself, management competencies relevant to action and decision-making are to be taught across the students' individual focal points. The understanding of management in the context of the degree program shows similarities to project

management as well as to entrepreneurial management. However, contrary to these narrowly defined management concepts, it emphasizes the systemic, complex and normatively controversial character of social resource utilization. Thus, goal definition, planning and reflection on management processes are important phases in sustainable resource management, as these steps allow for a fundamental adjustment of goals, strategy development and implementation. Similar to circular management concepts, the management approach in the degree program is based on a cyclical understanding of management processes, which emphasizes the incompleteness and complexity of the organization of social resource use, as well as the systemic networking of different resource use patterns with each other.

Accordingly, 8 phases of management can be named, which are constantly linked to each other in an unfinished circular process and continuously refer to each other:

- Situation analysis: analyzes the specific resource, political, legal and cultural framework conditions, normative demands on resource use and potential areas of conflict
- Definition of objectives: defines the specific objectives of resource management in consultation with the stakeholders, institutions and organizations concerned, taking into account transparent and comprehensible normative guidelines
- Planning: plans the deployment as well as the procurement and provision of the resources required to achieve the objectives
- Operationalization of the objectives: decides on the action program to achieve the objectives with the given resources
- Delegation and differentiation: delegates activities to the respective actors, institutions or organizations, including the definition of transparent sub-goals
- Coordination: coordinates the cooperation of the various functional areas
- Monitoring and evaluation: monitors the degree of achievement of the specific objectives, evaluates the strategies for achieving the objectives and their implementation
- Reflection and recalibration: final consideration and, if necessary, reorientation of the objective, renewed induction of a management process.

In the module "**Project Management, Public Relations and Cross Cultural Communication (CCC)**", students' skills in project management, intercultural communication, rhetoric, moderation and languages are promoted and developed.

In the module "**Introduction to Economics and Business Ethics**", students receive an introduction to economics with a focus on the social and ecological effects of economic activity and the responsibility that goes with it. „**International Environmental Governance and Conflict Management**“ offers an introduction to international environmental policy and its development. The focus is on the analysis of the impact of international environmental policy on the environment, based on relevant conflicts in the field of resource management. It is also important to work out solution strategies in the field of conflict management.

Depending on the focus of interest of the students, they can choose within these three modules and must achieve 10 CP. If the student is interested in economics, it is recommended to take the module "Introduction to Economics and Business Ethics" in combination with one of the two other modules. If students are interested in management, the combination of the modules "Project Management, Public Relations and Cross Cultural Communication" with "International Environmental Governance

and Conflict Management" is productive. Since both focal points are included in order to achieve the overall qualification goals of the program, the students can decide for themselves.

### 6.3 Sustainability and Nature Science Aspects

The area "Sustainability and Nature Science Aspects" represents a content-based introduction to the complexity of the topics of climate change, sustainability and global environmental change. Here, students gain insights into the different perspectives on the topic of sustainability of the various disciplines. Students take two modules here, each worth 5 CP. The modules of the "Sustainability and Nature Science Aspects" are:

- Natural Resources – Traits, Management, Theory of Sustainability
- System Analysis and Introduction to Ecology

In the module "**Natural Resources - Traits, Management, Theory of Sustainability**", lecturers from a wide range of research areas provide an insight into the thematic diversity and depth of content of resource management. In addition, students become familiar with the term sustainability and the concepts associated with it.

The module "**System Analysis and Introduction to Ecology**" teaches methods and tools of system analysis. Using ecology as an example, complex issues such as ecological concepts and processes are analyzed with the help of simulation models. In the process, students also receive an introduction to the fundamentals and essential interrelationships of ecology.

### 6.4 „Inventory Methods, Statistics and GIS“ and „Scientific Communication“

In the module "**Methods of Scientific Communication**", which comprises 4 CP, students are introduced to the topic of scientific work. The module is intended to prepare students from different disciplinary and international backgrounds for the generally applicable standards of scientific work, the mastery of which is indispensable for the further successful course of studies.

The module "**Inventory Methods, Statistics and GIS**" of 6 CP includes important planning, analysis and survey tools as well as evaluation tools for sustainable resource management, which are a prerequisite for the application-oriented elective modules starting in the second semester.

### 6.5 Elective Modules as of 2<sup>nd</sup> Semester

From the second semester on, students have the opportunity to choose elective modules according to their main interests. For this purpose, they can choose from 8 "Science Topics", which they can freely take in their 45 CP elective area.

The following 8 "Science Topics" and correspondingly assigned elective modules are offered in the program:

Table 1: Science Topics and Elective Modules

Science Topics	Elective Modules			
<b>Management and Protection of Forest Ecosystems</b>	Forest Management	Forest Growth and Forest Operations	Genetic Resources Management and Forest Protection	Plantation Forestry and Agroforestry
<b>Wildlife and Protected Area Management</b>	Protected Areas Biodiversity and Management	Wildlife Management and Wildlife-Human Interactions	Fisheries and Aquatic Conservation	Wildlife and Conservation Biology
<b>Climate, Air and Water</b>	Climate Change - Science, Adaptation, and Mitigation	Mountain Catchments under Changing Climate	Environmental monitoring and data analysis	Hydrometeorology and management of water resources
<b>Soils and Soil Management</b>	Introduction to Soil Science	World Soil Resources	Soil Protection	Analytical Characterization of Soil Resources
<b>Material and Waste Management</b>	Material Flow Management and Applications	Waste and Waste Water Treatment	Emission Control in Land-Use and Animal Husbandry	Utilization and Treatment of Special Materials and Waste
<b>Renewable Resources</b>	Renewable Energy Technologies	Bioenergy Systems	Forestry Raw Materials and their Utilization	Political and Social Perspectives of Renewable Resources
<b>Landscape Management</b>	Vegetation Ecology and Geographical Information Systems	Remote Sensing and Image Processing	Landscape Planning	Landscape Management – Application Study
<b>Sustainable Agricultural Value Chains</b>	Supply Chain Management and Sustainability in Agribusiness and the Food Industry	Sustainability: Paradigms, measurement systems, and	Cooperation and integration in agricultural value chain	Network and stakeholder analysis: Sustainable resource use and agri-food systems

In the "Science Topics", the methods learned in the first semester are applied using selected natural resources as examples. The focus is on the development of concepts for the sustainable use of the resources dealt with, taking into account ecological, economic and socio-political factors. In principle, students are free to choose the modules from the "Science Topics". Due to the complexity of some topics, modules from the "Science Topics" can build on each other. In this case, recommendations are made to choose certain modules in a coherent way.

After participating in the specialization area "**Management and Protection of Forest Ecosystems**", students understand the socio-political, economic and ecological significance of forest ecosystems. They know the basics of sustainable forest management and are able to analyze the ecological interrelationships with significance for forest growth and to apply their knowledge for the sustainable use and protection of forest ecosystems. In addition, students are taught technical skills in the field of silvicultural planning, forestry technology and forest management planning.

In the specialization area "**Wildlife and Protected Area Management**", students are taught skills related to the protection and management of wildlife and their habitats. Graduates understand the relevant ecological relationships and are able to derive from these the essential principles of sustainable wildlife and protected area management. They know the importance of protected areas for nature conservation and environmental protection as well as for environmental education and are able to develop concepts for the sustainable use of these areas. They are able to identify possible conflicts of interest and to develop appropriate solution strategies.

After participating in the specialization area "**Climate, Air and Water**", students understand the importance of climate, water and air in ecosystem management and are able to assess the main impacts of changing environmental conditions. They know different analytical methods for quantitative and qualitative characterization of climate and water properties and are able to apply them and interpret the obtained results. Furthermore, they are able to make statements about possible future developments and to develop concepts for sustainable land use in the water nexus and for climate protection.

After participating in the specialization area "**Soils and Soil Management**", students understand the role of soils in terrestrial ecosystems. They know the physical, chemical and biological properties of soils, understand their genesis and can assess the potential of their use and the threats to their functions for all soils of the world. They master the most important methods for addressing soils in the field and for analysis in the laboratory and can interpret the analytical results. They are able to characterize soils in terms of their natural fertility and in terms of human-induced degradation. They are able to develop concepts for the remediation of contaminated soils. They know the central importance of soil in the global carbon cycle and climate change.

In the "**Material and Waste Management**" specialization area, students are taught skills in the area of goods, material, substance and residue management. Graduates understand various methods of residual material disposal and can apply their knowledge to different problems. They know the methodical basics for system analysis and determination of material and substance flows and, based on this, are able to independently develop concepts for resource and residual substance management, taking into account aspects of resource availability and environmental impact. In doing so, they are able to apply evaluation methods and to check different environmentally compatible variants and to consider aspects of air, soil, water and health protection.

Graduates of the "**Renewable Resources**" specialization area understand the significance, potential and possible applications of various renewable raw materials and regenerative energy sources. They are familiar with the essential process steps of the different utilization lines with their respective advantages and disadvantages and are able to assess the economic and ecological consequences of different forms of utilization. They are also able to assess potentials and risks with regard to the use of regenerative energy sources. Furthermore, the graduates know the most important basics of plant breeding and understand their importance in relation to renewable resources.

After completing the specialization area "**Landscape Management**", students are able to plan and implement measures for the development of the landscape under the premise of sustainable development on the basis of comprehensive analyses. To this end, they are familiar with the most important survey, analysis, planning and evaluation procedures and are able to coordinate these and apply them independently. In particular, the students are able to use the possibilities of geographical information systems. Furthermore, they are able to assess the effects of interventions in the landscape and to apply suitable techniques for the limitation and elimination of damages.

Graduates of the specialization area **"Sustainable Agricultural Value Chains"** understand the relationship between agricultural production systems and value chains and their social and environmental performance and impacts. They are able to develop, improve and apply relevant sustainability related indicators. They are able to analyze and assess the sustainability of agricultural value chains and the associated collaborations.

In addition to the elective modules offered in the "Science Topics", students can choose from a range of elective modules that are not assigned to a "Topic". The following elective modules are part of the subject examination regulations and can be taken freely by the students:

- Environmental and Natural Resource Economics (5CP)
- Sustainable and Environmental Regulations (5CP)
- Climate Change Economics (5CP)
- Human Resource Management (5CP)
- Wildlife Monitoring in Ecology: Concepts, Methods and Application (5CP)
- Economics of water use, regulation and markets (5 CP)

In addition, students may also choose from a selection of elective modules not specified in the subject examination regulations:

- Energy Transformation
- Introductory Lecture Politics and Technology
- The Political Economy of Standards and Certification
- The Politics of Market Competition in a Global Economy
- Modeling and Optimization in Energy Markets
- Transportation Economics
- Basic Mathematical Tools for Imaging and Visualization
- Integration of Renewable Energies
- Advanced Environmental and Natural Resource Economics

In the module "General Education Subject", students take a general education subject worth 3 CP according to their personal interest.

## 6.6 Internship

Students in the master's program must complete a professional internship of at least eight weeks in the field of resource management. The internship is intended to give students an insight into the wide range of activities in the field of sustainable resource management and an understanding of its different significance outside of university education. In addition, the internship offers the opportunity to already establish contacts with potential employers. The internship can be completed either in the home country or abroad. In the context of the internship, the writing of an internship report is required.



## 6.7 Master's Thesis

The fourth semester of the program is completely available for the preparation of the Master's thesis. The Master's Thesis comprises 30 credits and can be freely chosen by the student. At the beginning of the thesis, the student defines a project plan with the respective supervisor and prepares a topic-related Master's thesis proposal.

In the Master's thesis, students demonstrate that they are able to work independently on a topic in the field of sustainable resource management using scientific methods. In doing so, the students apply the skills they have learned in the modules of the program in the area of scientific work and project management.

## 6.8 Studiability and Mobility Window

The systematic structure of the master's program "Sustainable Resource Management" allows for the non-overlapping offer of compulsory courses and allows students to graduate within the standard period of study. Figure 8 shows a possible scenario of how the program could be studied. In this example, the modules "Introduction to Economics and Business Ethics" and "Project Management, Public Relations and Cross Cultural Communication" were chosen in the compulsory area "Management Aspects" in the first semester. In the elective area, modules from the fields of "Climate, Air and Water" and "Management and Protection of Forest Ecosystems" were selected. From these "Science Topics", 3 modules were taken to deepen the knowledge in each of the two areas. In the further elective area, the modules "Climate Change Economics", "Human Resource Management" and "Environmental and Natural Resource Economics" were chosen.

Figure 8 Exemplary and non-overlapping curriculum of the master's program Sustainable Resource Management

semester	modules					credits	
1.	<b>WZ1823</b> Inventory Methods, Statistics and GIS (required)  K 6 CP	<b>WZ2713</b> Methods of Scientific Communication (required)  W 4 CP	<b>WZ1821</b> Natural Resources-Traits, Management and Theory of Sustainability (required)  K 5 CP	<b>WZ1824</b> System Analysis and Introduction to Ecology (required)  K 5 CP	<b>Management Aspects (required)</b>  at least two of these three modules (5 CP each):  WZ2712 Project Management and Cross Cultural Communication (PA)  <i>and/or</i>  WZ1822 Introduction to Economics and Business Ethics (K)  <i>and/or</i>  W1000926 International Environmental Governance and Conflict Management (W)  10 CP	30	
2.	<b>mobility window</b>  <b>Internship (required)</b>  The duration of the internship is 8 weeks.		<b>Science Topics (elective)</b>  A minimum of six modules must be selected from a total of eight Sciences Topics.  <u>Science Topics Block A:</u> – Management and Protection of Forest Ecosystems – Material and Waste Management – Landscape Management – Soils and Soil Management		<b>Free elective modules</b>  An additional 15 CP must be earned from the free elective modules.	<b>WZ2714</b> General Education Subject (required)  At least 3 CP from the courses offered by the Carl von Linde Academy,	30
			<b>Science Topics Block B:</b> – Renewable Resources – Climate, Air and Water – Sustainable Agricultural Value Chains – Wildlife and Protected Areas  Modules from block A can be combined with modules from block B without overlapping. It is recommended to choose one area from each block.		Unternehmen I UM and Sprachen Akademie must be earned.		
3.	SL 12 CP		30 CP		15 CP	3 CP	30
4.	<b>WZ2745 Master's Thesis (required)</b>  W 30 CP					30	
dark blue = compulsory module Master's Thesis grey = general compulsory modules green = compulsory modules sustainability and nature sciences aspects orange = compulsory modules management aspects medium blue = compulsory modules internship light blue = elective modules science topics white = free elective modules					CP = credit points; K = klausur (written exam); PA = project work; W = research paper; SL = frail credit requirement		

## 7 Organization and Coordination

The master's program Sustainable Resource Management is offered by the TUM School of Life Sciences.

Areas of responsibility might be listed as follows:

The following administrative tasks are performed partly by the TUM Center for Study and Teaching (TUM CST) and its administrative units, partly by offices in the schools or departments:

- Student Advising: Student Advising and Information Services (TUM CST)  
[studium@tum.de](mailto:studium@tum.de)  
 +49 (0)89 289 22245  
 Provides information and advising for prospective and current students (via hotline/service desk)
- Departmental Student Advising: Dr. Eva Bauer  
[srm.co@ls.tum.de](mailto:srm.co@ls.tum.de)  
 +49 (0)8161 71 4464
- Academic Affairs Office (within department/school), Infopoint, etc.: Campus Office Weihenstephan  
[campus.office@ls.tum.de](mailto:campus.office@ls.tum.de)
- Study Abroad Advising/ Internationalization: TUM-wide: TUM Global & Alumni Office  
[internationalcenter@tum.de](mailto:internationalcenter@tum.de)  
 Departmental: Campus Office Weihenstephan  
[international.co@ls.tum.de](mailto:international.co@ls.tum.de)  
 +49 (0)8161 71 3163
- Gender Equality Officer: Prof. Aphrodite Kapurniotu  
[akapurniotu@mytum.de](mailto:akapurniotu@mytum.de)
- Advising – Barrier-Free Education: Service Office for Disabled and Chronically Ill Students (TUM CST)  
[handicap@zv.tum.de](mailto:handicap@zv.tum.de)  
 +49 (0)89 289 22737
- Admissions and Enrollment: Admissions and Enrollment (TUM CST)  
[studium@tum.de](mailto:studium@tum.de)  
 +49 (0)89 289 22245  
 Admissions, enrollment, Student Card, leaves of absence, student fees payment, withdrawal

- Aptitude Test (EV):

TUM-wide: application and enrollment (TUM CST)  
 Departmental: Campus Office Weihenstephan  
 Dr. Sabine Köhler  
[application.co@ls.tum.de](mailto:application.co@ls.tum.de)  
 +49 (0)8161 71 3336
- Semester Fees and Scholarships:

Fees and Scholarships (TUM CST)  
[beitragsmanagement@zv.tum.de](mailto:beitragsmanagement@zv.tum.de)  
 Scholarships and semester fees
- Examination Office

Central Examination Office (TUM CST)  
 Graduation documents, notifications of  
 examination results,  
 preliminary degree certificates
- Departmental Examination Office:

TUM School of Life Sciences;  
 Campus Office Weihenstephan  
 Team Examination Office  
[examination.co@ls.tum.de](mailto:examination.co@ls.tum.de)
- Examination Board:

Prof. Dr. Gabriele Weber-Blaschke (Chair)  
 Susanne Minges (Secretary)
- Quality Management -  
 Academic and Student Affairs:

TUM-wide: Study and Teaching -  
 Quality Management (TUM CST)  
[www.lehren.tum.de/startseite/team-hrs/](http://www.lehren.tum.de/startseite/team-hrs/)

Departmental: Campus Office Weihenstephan  
 Team Quality Management  
[qm.co@ls.tum.de](mailto:qm.co@ls.tum.de)  
 Organization QM Circle, Evaluation, Coordination  
 Module Management

## 8 Enhancement Measures

Considerations on the sustainability of the use of our natural resources gained a lot of attention towards the end of the last millennium. The World Summit in Rio de Janeiro (1992) on the relationship between environment and (economic) development brought movement into the discussion, which had already begun in the early 1970s with the studies on "Limits to growth" in the general public. It was clear that this challenging issue could only be tackled on an international level. Against this background, a small group of Weihenstephan forest scientists conceived a broad-based international course of study that covered important areas of sustainable resource use and extended far beyond the purely forest science horizon. Fortunately, the German Academic Exchange Service granted generous start-up funding so that the degree program could begin with about 20 students and with the help of broad support from many disciplines at the Weihenstephan campus in 2001.

Since then, demand for places has increased steadily, reaching a consistently high level of around 400 to 600 applications per year. To date, students from more than 90 different countries have been admitted to the Master's program "Sustainable Resource Management". Especially students from the fields of engineering and economics see very good complementarity in our course of studies to their previous knowledge. The course has been reformed several times. First, the choice of semesters was extended from three to four. Elective options and aspects of flexibility have been continuously and specifically improved. The principle of educating generalists in the diverse aspects of sustainable resource management is a shared guideline for the degree program.