



Degree Program Documentation Master's Degree Program

Part A

TUM Department of Aerospace and Geodesy
Technical University of Munich

General Information

- Administrative responsibility: Department of Aerospace and Geodesy
- Name: Land Management and Geospatial Science
- Degree: Master of Science (M.Sc.)
- Standard Duration of Study & Credits:
4 Semesters and 120 Credit Points (CP)
- Form of study: Full Time
- Admission: Aptitude Assessment (EV)
- Start: Winter Term (WiSe) 2020/2021
- Language of Instruction: English
- Degree Program Director: Prof. Dr. Walter Timo de Vries
- Contact Person for further questions:
Dr. Pamela Durán Díaz
pamela.duran@tum.de
089-289-25789
- Status as of: 19.06.2020

Directory

1	Degree Program Objectives	4
1.1	Purpose of the Degree Program	4
1.2	Strategic Significance of the Program	6
2	Qualification Profile	8
3	Target Groups	10
3.1	Target Audience	10
3.2	Program Prerequisites	10
3.3	Target Numbers.....	11
4	Analysis of Need	12
5	Competition Analysis	14
5.1	External Competition Analysis	14
5.2	Internal Competition Analysis.....	17
6	Program Structure	19
7	Organization and Coordination	23
8	Enhancement Measures	26

1 Degree Program Objectives

1.1 Purpose of the Degree Program

In both industrialized and developing countries, there is a high demand for policies, tools and instruments in order to cope with the increasing globalization, climate change and migration patterns, as well as with the cross-border nature of many land-related problems. Based on national and international experiences, the degree program Land Management and Geospatial Science aims to train responsible professionals who will have expertise beyond borders when managing the built environment, developing infrastructures and using natural and human resources, and develop creative and innovative solutions.

Land management is a specific scientific field that aims, amongst others, to describe and analyze the relations between people and land (land tenure), and to ensure that the land-and-people relationship is protected to give socioeconomic and environmental benefits (land tenure security). It also includes designing and measuring the size of land and buildings and allocations of land parcels, designing and evaluating the effectiveness of methods to avoid conflicts in access to land (land governance/policy), as well as measuring and reducing transaction costs for buyers and sellers of land and real estate (property valuation).

Geospatial science aims at describing, analyzing and understanding the relations between spatial objects and spatial phenomena. Geospatial Science is a branch of engineering that derives practical solutions based on a specific perspective and logic: it spatially measures and analyzes objects and subjects, and uses spatial information technologies to provide practical legal, social, and spatial solutions to problems with land ownership, land use, real estate, and territorial boundaries.

In summary, land management and geospatial science are two inter-connected scientific domains. The connection is relevant to solve specific societal challenges, such as land and property registration, management of rights and restrictions in land, water and environment.

A number of key international documents currently shape the field of land management and geospatial sciences:

- The core functional concepts of responsible land management and responsible land administration, developed in (de Vries & Chigbu, 2017), (Zevenbergen, de Vries, & Bennett, 2015) and (BMZ-GIZ, 2016)
- The land management and land administration paradigms, as presented in (Magel, Thiel, & Espinoza, 2016), (Williamson, Enemark, Wallace, & Rajabifard, 2010)
- Four international documents: Voluntary guidelines of responsible land tenure (FAO, 2012), The Continuum of land rights (GLTN (Global Land Tool Network), 2015), The fit-for-purpose land administration (Enemark, Bell, Lemmen, & McLaren, 2014) and The land administration domain model (Lemmen, van Oosterom, & Bennett, 2015).

These documents argue that society needs the combined insights of land management and geospatial sciences to ensure:

- that the processes and regulation of land reform and redesign of physical infrastructures are carried out efficiently and effectively,

- that these processes are spatially just, i.e. based on the principle that every person in the world should have the right to use and/or own land, houses and buildings, and
- that in each location the same principles of allocation exist.

In real life practice, Land Management experts and Geospatial Engineers work together to use new (and evolving) technologies to solve land/spatial problems in interconnected and geographically informative ways, to reveal new insights about societies, the environment, the earth, development policies and issues related to global (including local and national) agenda on development. When combining both sciences it is possible to design and implement cadasters and land registration systems, to establish and facilitate the spatial regulation needed for measuring and checking the size, shape, quality and value of properties, and to measure and regulate urban expansion and handling of informal settlements. It becomes possible to make use of the logic and principles of geospatial science and geo-information tools, which are particularly valuable for understanding where and why land conflicts occur, how and where to establish land and construction rights, to monitor as well as to analyze the spatial distribution and changes in house prices and housing rents.

From the above one can derive that LMGS is a transdisciplinary field, which is positioned between the main studies of civil and environmental engineering geodesy, landscape architecture, governance, politics, spatial planning and management. The aim of the degree program is to contribute to the development of creative, innovative and feasible solutions for complex spatial problems. The nature of these problems is threefold:

1) Contextual: Problems related to the interplay of stakeholders within a local political, social, legal and institutional system, where no one-off, blueprint solutions for each and every country of location are applicable. Laws and public administration differ per location. Hence, one needs varying tools to understand and describe them.

2) Technical-methodological: issues related to geospatial tools and instruments, such as (cadastral/ parcel-based, land) information systems, methodologies, instruments, and regulation with which land and geospatial interventions are prepared, executed and monitored as well as geospatial technologies, which can capture, monitor, store and query multi-dimensional information on land.

3) Complex, volatile and unpredictable: i.e. Problems related to sensible and unpredictable people-to-land relations and stakeholders' unpredictable reactions to external (government or privately induced) interventions. In addition, natural risks and disasters, such as earthquakes or tsunamis, or people-induced disasters, such as geopolitical conflicts or boundary conflicts, have proven to be highly uncertain. Hence, one needs proper capabilities to handle social conflicts and complex and uncertain physical events.

Deriving solutions thus typically requires a combination of contextual insights, technical-methodological instruments and conflict resolution skills. The LMGS program is designed to deal with all three aspects. The program has an international and multidisciplinary character. The master's program aims at transferring knowledge and skills through the sensitization towards anthropogenic environments and issues, and the recognition of cultural assets as drives for development. This complies with international standards and values or principles, which imply a strong commitment to the improvement of the society as a whole.

1.2 Strategic Significance of the Program

The specific combination of knowledge in both land management and geospatial sciences will enable graduates to fill the professional void currently existing. Such professionals connect engineers and architects on the one hand with real estate managers and politicians on the other hand. This bridging activity can support the decision making process on where the physical structures should be and how they are managed. Such professionals will have to deal with both the technical aspects of site planning and spatial planning, land and spatial planning laws and regulations, and make use of management skills in order to reconcile people's needs, power, influence and decisions.

LMGS is one of the degree programs of the Department of Aerospace and Geodesy, which is committed to "Mission Earth", covering research areas from the analysis and representation of geodata in order to monitor climate change, to finding new solutions for urban air mobility. The measuring, analysis and categorization of land and infrastructure, designing and securing structures both social and technological, and understanding processes within, at the surface and above planet earth are key aims of the department. All these require affinity with multiple technical disciplines and sensitivity of the social environment in which technical solutions are situated. The LMGS master fits within these aims of the department. The trans-disciplinarity of the LMGS master program contributes to developing and implementing knowledge in and beyond Bavaria, with international cutting-edge researches and implementations.

The LMGS master is a manifestation the department's mission of transferring knowledge and applying it to practical cases, which was a goal when developing the degree program: the theoretical approach as the state-of-the-art in land management leads to the acquisition of the technical skills, which are later applied to concrete case studies, which are offered throughout the degree program. A stay abroad is possible in the third semester, where students pick elective modules from within three different areas of concentration. The study is usually completed with a concrete research project.

The LMGS Master program is closely connected to the programs of the geodesy cluster, including Geodesy & Geoinformation, Cartography, and ESPACE. The overarching goal of all these programs is to prepare students for professional, entrepreneurial and academic activities which are primarily geared to monitoring earth from space, creating new visual representations of our human environment, as well as the management of data about the earth's surface to the natural resources below. The geodesy cluster has a particular attention for maintaining constructing and maintaining information of objects in space by defining measuring, evaluating, visualizing, mapping geospatial objects and their geospatial interrelations, and populating databases with such information. LMGS is specifically concerned with the object information, such as mapping of parcels, buildings and administrative areas, and connecting these to information about people, via land rights relations, land use relations, land value relations and land development relations. For graduates of LMGS it is important to be able to recognize and register such people-to-land (spatial) relations, and creating, changing and managing these, in order to support interventions in space, such as (re-)construction of roads, infrastructure and green areas.

Within the Department of Aerospace and Geodesy, the LMGS master's program contributes with a specific set of knowledge domain and tools to administer and regulate the management of both agricultural areas, built-up areas, water areas and green areas. Specific of the LMGS is the emphasis

on regulatory tools and instruments to measure, monitor, categorize, legalize and formalize spatially distributed objects and areas.

For a number of reasons LMGS is a separate program of its own kind and with its own relevance:

- The international development character: The specific focus on applying the obtained skills and knowledge to development and in developing/transition countries. The LMGS program is less geared towards employment in the German or European market, unless there is a particular development connection (such as within BMZ/GIZ). Hence, TUM acts as a knowledge hub in which international experts and students share and develop new knowledge about land management.
- The relatively narrow knowledge field of land information systems, cadastral data, and land registration in the context of developing countries: Given that the majority of land is unregistered in these countries, this specific knowledge on how to adopt appropriate land information (digitization) policies in a developing context involves the development and implementation of new technologies (such as voluntary geographic information, fit-for-purpose cadastres). This would not be possible with conventional European knowledge and resources.
- The combination of specific socio-legal knowledge and skills with geospatial knowledge and skills: Conventional geodesy and geo-information or spatial planning programs tend to emphasize the formal (based on written law) aspects of describing and constructing built-up land, and de-emphasize the informal (based on customs, traditions, continuum of rights) character of legitimate land rights, land and geospatial interventions. How to handle such aspects is a particular component of this degree program.
- Compared to other studies at TUM, LMGS is specifically addresses rural problems in developing and transition countries. This includes informal (unregistered) but legitimate land rights, unplanned settlements and rapid urban growth, dynamic and contested land use, as well as multiple and contradictory land claims.

2 Qualification Profile

The LMGS program generates socially and politically sensitive engineers who are capable to design solutions for land related problems given a specific legal and/or societal context. Such graduates are able to develop creative, innovative and feasible solutions for complex spatial problems, they are able to perform their professional competences in different locations, and they can customize solutions with mediation and conflict resolution competence. Regardless of the self-chosen type of area of concentration all students are particularly able to:

- Understand that land and geospatial interventions are connected to multiple perspectives one can have on land issues.
- Develop innovative and creative solutions in a changing technical and social environment
- Research land related problems from a multi-disciplinary perspective.

All graduates gain basics of the following categories, but within their self-chosen area of concentration they are able to deepen them even more. The specific qualifications of such professionals can be classified in three category types as detailed below:

1. Land management professional skills
2. Usage of geospatial methods and techniques
3. Political and organizational aspects of land and geospatial interventions

The emphasis of the first qualification type (1.) lies more on land management professional skills: land as physical entity, land as an asset, land as a home for a community and land as a legal security. Such a basic understanding allows to and requires to:

- Apply methods and techniques to prepare, implement and assess land and geospatial interventions in a responsible and sustainable manner.
- Use economic techniques to assess whether a land and geospatial intervention is cost efficient and cost effective.
- Make use of legal acts, regulations and procedures in order to design and execute a land and geospatial intervention according to the law.
- Make use of and rely on conventions related to informal and customary land interests, so that land and geospatial interventions can also be managed in areas where formal legal regulations are not applicable. It is particularly relevant to know how to deal with intangible land values, such as tenure security, the role of women, and customary rights systems.
- Design land information systems which maintain information about land rights, land use, land value, and restrictions on land.

The second category of qualification (2.) refers to the fact that land and geospatial interventions are principally interventions in space. As a consequence, a core qualification is the ability to make use of geospatial methods and techniques which help to locate, design, measure and analyze the impact in space. More specifically this includes:

- Application of airborne and space technologies which can capture information about spatial boundaries, land use, land cover, and spatial changes
- Application of geospatial and geodetic tools systems to connect land related information (such as locations of parcels and buildings) to fundamental geodetic reference systems (such as heights above sea level or international coordinate reference systems)
- Application of geospatial technologies to monitor, measure and manage land related information
- Design and utilization of technical systems which can support decision making on land related issues

The third type of qualification (3.) relates to making land and geospatial interventions politically and organizationally feasible and executable. LMGS professionals and scientists need to be able to translate complex technical and legal matters for policy makers and politicians. In order to be able to do that they have to rely on skills in:

- Understanding and using institutional and organizational systems in which land policies are administered, governed, prepared, discussed, designed and enforced
- Connecting land related problems to problems of water, agriculture, environment, forest, housing and socio-economic development
- Communicating with stakeholders at all levels of administration and in all sectors of society (in English)

Finally, all students gain the ability to research land related problems from a multi-disciplinary perspective; they also contribute to deriving new insights to LMGS concepts and theoretical frameworks and derive meaningful policies based on analyzed information. This implies that LMGS professionals and scientists need to have the ability to:

- Theorize about real-life problems with land and geospatial concepts and methods
- Apply land and geospatial concepts and methods to derive meaningful and innovative insights and feasible solutions
- Report and communicate research results to policy and politics realms.

3 Target Groups

3.1 Target Audience

The degree program addresses national and international applicants, who are particularly interested in land issues in developing contexts. Before entering the LMGS program candidates should have a basic understanding of (geo)spatial reasoning, information sciences and have some affinity with land related issues. The required academic background for applicants is a Bachelor's degree in one of the following fields: land administration, land use planning, urban and rural development, land surveying, geodesy, land valuation, land development, land economics, architecture, civil engineering, environmental engineering, geomatics, geoinformatics, spatial planning, geography, real estate studies or property law.

3.2 Program Prerequisites

The program is aimed at applicants which are capable of handling complex problems in land matters which usually only tend to have customized and contextually relevant solutions. In addition, applicants should demonstrate good command of the English language, and should have good communication skills. Therefore, during the application process the applicants have to hand in:

- Letter of Motivation (of minimum of 800 words and maximum of 1500 words).
- English Language certificate; acceptable certificates are:
 - ✓ Certificate for Test of English as a Foreign Language (TOEFL) with a minimum of 88 (Internet-based).
 - ✓ IELTS: Band Score 6.5; academic module or Cambridge Main Suite of English Examinations
 - ✓ Proof of English as a language of instruction in "Diplom" or Bachelor's degree program

Proof of English language proficiency can further be shown demonstrated through a language qualification of at least 3 credits at the level C1 of the European Framework of Reference for Languages. The completion of 12 or more credits for English language courses at the undergraduate level can also be accepted as proof of language proficiency.

With reference to the above list, proficiency test certificate of IELTS, TOEFL or Cambridge Main Suite of English Examination are required for non-native English speakers, unless they already hold an academic degree in which the medium of instruction was English. Native English speakers or applicants who have completed an academic program (Bachelor's or Master's) in English, do not need to submit the results of an English proficiency test. Applicants who have completed a program in English must submit a certificate of medium of education (English) from the respective institution. The procedure for enrolment involves candidates enrolling through TUM's online portal. One by one oral interviews are conducted in person (in cases where candidates are able to make themselves physically available) or by telephone (in cases where candidates are unable to be physically present). The results of preliminary assessments and interviews leads to the ranking of candidates to be presented to a selection committee, consisting of the Dean of Studies, Program Director and

Program Coordinator. It is the committee that determines who is finally accepted or rejected for admission.

3.3 Target Numbers

The program aims at attracting 20-30 students per year. This is a reasonable estimation based on numbers of a previous TUM study program (Land Management and Land Tenure – LMLT). Even though LMLT, which was operating in a similar domain, targeted a more narrowly described target group in developing countries only, it had 15-20 students each year. Each of the alumni have obtained jobs within a few months, both in science, commercial and professional firms, government, and development agencies. As compared to this previous program, the LMGS program graduates would have additional competences, more study time, and a broader education. This would enhance their job opportunities in a wider field of socio-technical jobs. This wider perspective as compared to the previous program also justifies a moderate increase of numbers to 20-30 students per year for LMGS as compared to LMLT.

4 Analysis of Need

LMGS aims at creating professionals which will be able to work effectively at national, international and multilateral organizations and which require skilled workers to deal with land policy, land governance, land development, spatial planning, urban and rural development. In total, some 20-30 students can be trained each year. The following types of organizations have the following estimated capacity needs which the LMGS program supplies:

- National and local cadastres and land registrations organizations need staff members who can design and manage land information systems, which can deliver information services (on existing land rights, land use, land value, spatial restrictions) to notaries, planning agencies, buyers and sellers of houses and land and real estate agencies. Each country should have at least one cadastral agency. On average, each cadastral agency needs approximately 10-15% of their staff members to have a solid background in land management and geospatial sciences at Master's level. Out of this group, at least 2-3 students each year would need to be trained.
- Spatial development agencies require staff members who are capable of evaluating where and why land related problems occur and how these can be solved given a local political context. On average, each spatial development agency needs approximately 10% of their staff members to have a solid background in land management and geospatial sciences at Master's level. Out of this group, at least 3-5 students would need to be trained each year.
- NGOs and interest groups concerned with land reform, land rights, land restitution rely on educated staff members who do not only have a solid background in legal issues, such as land rights, but also in technical issues, such as how to register land rights in information systems, and how to convince politicians on alternative land management solutions. On average, each of such agencies needs approximately 30% of their staff members to have a solid background in land management and geospatial sciences at Master's level. Out of this group, at least 3-5 students would need to be trained each year.
- Ministries for land, housing and (re)settlement typically need to design national land policies, which are in line with other spatial policies. As a result, they require capacity in land management and geospatial science in order to design and compare scenarios, both as discussion and consultation documents and as final land policies. On average, each Ministry needs approximately 5-10% of their staff members to have a solid background in land management and geospatial sciences at Master's level. Out of this group, at least 3-5 students would need to be trained each year.
- Municipalities are often responsible for raising land taxes and drafting land policies. Out of this group, at least 1-3 students each year would need to be trained.
- Authorities, private companies and NGOs involved in spatial planning. Out of this group, at least 1-3 students each year would need to be trained.
- European and UN agencies dealing with land politics. Out of this group, at least 1-3 students each year would need to be trained.

- Authorities, private companies and NGOs dealing with land development, participation and community development (e.g. regional land development agencies, urban or rural planning actors, village and city administrations). Out of this group, at least 1-3 students each year would need to be trained.

5 Competition Analysis

5.1 External Competition Analysis

There are few similar programs which combine the domain of land management or closely related fields (such as geodesy, civil engineering, spatial planning, and landscape architecture) to development. In Germany these are:

- Geodesy and Geoinformatics, Leibniz Universität Hannover
- Geodetic Engineering, Universität Bonn
- Geodäsie und Geoinformation (Vertiefung Landmanagement), Technische Universität Darmstadt
- Geoinformatik und Landmanagement, OTH Weiden-Amberg

Internationally there are a number of Master's programs, which offer a similar combination of a focus on land and a focus on development.

Comparable international programs include:

- Geoinformation Science and Earth Observation (specialization Land Administration), University Twente / ITC, The Netherlands
- Spatial Engineering, University Twente / ITC, The Netherlands
- International Land and Water Management, Wageningen University, The Netherlands
- Spatial Development and Infrastructure Systems, Eidgenössische Technische Hochschule Zürich (ETH Zürich), Switzerland
- Bioscience Engineering: Land Management, KU Leuven, Belgium
- Surveying, Planning and Land Management with specialization in Land Management, Aalborg University, Denmark
- Rural Estate and Land Management, Harper Adams University, UK
- Rural Land and Business Management, Spatial Planning and Development, University of Reading, UK
- Surveying and Land/Environmental Management, University of Exeter, UK
- Environmental Surveying, Birmingham City University, UK
- Environmental Sciences, Policy and Management (MESPOM), Central European University, Hungary

Compared to other programs, LMGS is different in the following regards:

- LMGS considers land management broader than only land administration and the application of geospatial technologies for land administration. As LMGS professionals will work at the interface of politics and technology, they need to be able to judge the relevancy of certain geospatial technologies in a broader spectrum of land management applications. The other programs are either more tool oriented (e.g. focusing on the

development and application of GIS technology) or focus more on an entirely different sector (e.g. environment). LMGS focuses on designing and evaluating interventions, which help to redistribute socio-legal aspects of land rights, land access and land use in a multidisciplinary and responsible manner.

- Within LMGS there is comparatively much more attention on ‘fit-for-purpose’ and adaptable technical-legal aspects of land rights, land registration and cadastral systems. As such systems need to be designed for specific contexts, the skills and knowledge about how to align geospatial technological needs to specific legislative and socio-economics contexts (which can differ from country to country and region to region) is much more crucial than within other degree programs. In addition, there is more attention on how to deal with informal systems alongside formal systems.
- The relation of land use and land rights as part of development strategies is more prominent in LMGS as compared to other programs.
- There is more specific attention for intangible land values (such as tenure security, role of women, customary rights systems) as compared to focus on economic and financial values which are in other programs.

The LMGS master’s program is unique in its holistic view of land management. LMGS has a number of unique selling points:

- The international development scope. The program is built on a fundamental assumption that management of land and land related problems does not stop at the borders. Knowledge and skills need to be shared internationally, and solving land management problems requires social sensitivity and cross-cultural interaction. In the module land management this is addressed by discussing the relevance of social context for establishing and recognizing land rights. Social context is different per region and per country. Hence, during class there are several exercises which rely on international examples of land management problems. In addition, the module geoinformatics works with maps and spatial data from different countries. Hence, the students learn to work with data formats which tend to differ from country to country.
- The development of technical skills for which TUM is internationally recognized, applied to challenging case studies abroad
- Through the ‘open’ elective semester each student has the possibility for knowledge mobility and design their own type of specialization – either more land tenure systems oriented, more geospatially oriented, or more planning and governance oriented. These options make this program unique. In the required modules the teaching and exercise materials rely on international and cross-disciplinary case studies and examples.
- Career and research opportunities in international organizations. In the same way as for the topic formulation the students benefit from the already existing alumni-network of the former Master’s degree program Land Management and Land Tenure (LMLT). The degree program coordinator is also using established contacts for ongoing research projects in target countries for field research. Besides that, in order to keep the network alive and fully functioning, summer schools and refresher courses are organized regularly in different locations for our alumni all over the world. (e.g. Ghana refresher

course in summer 2017, China summer school in 2017, refresher course in Indonesia in 2016). The LMGS will be actively maintained and grown.

5.2 Internal Competition Analysis

There are 7 programs at TUM with which the LMGS program has some connection. These include:

- Master Geodesy and Geoinformation (“GuG”) – Department of Aerospace and Geodesy (LRG)
- Land Management (Partial Bachelor’s degree, “BoLe”) – Department of Aerospace and Geodesy (LRG)
- Civil Engineering (“BI”) – Department of Civil, Geo and Environmental Engineering (BGU)
- Environmental Engineering (“UI”) – Department of Civil, Geo and Environmental Engineering (BGU)
- Architecture (“AR”) – Department of Architecture (AR)
- Landscape Architecture (“LA”) – Department of Architecture (AR)
- Sustainable Resource Management (“SRM”) – School of Life Sciences (WZW)

Common themes of interest in all these degree programs include:

- Geospatial technology (similar to GuG). However, in the GuG program the emphasis is on learning the conceptual design and development of geospatial technology rather than the embedding and application of the geospatial technology in organizational, political and legal processes for land interventions. For example, students of GuG learn how to design photogrammetric systems, whereas in LMGS students embed and apply photogrammetric technology in land policy design and evaluation processes. Similarly, designing parcel-based land information systems, (open) cadasters and using multiple aspects of land informatics is the type of geospatial expertise, which is embedded in LMGS.
- Addressing housing and property issues (similar to BI/UI/AR). Compared to BI/UI and AR the issue of ownership and property rights is much more elaborate. It is crucial for LMGS to know about property rights and how to reform, re-shape and re-allocate property rights, both in formal and informal shapes. Applying this knowledge in both land management interventions and in shaping the built-up environment is a service which LMGS professionals provide to BI, UI and AR professionals. The depth of teaching in these subjects is therefore more profound. Hereby it is crucial that the focus is on designing multi-level land policies, which connect land rights to land development.
- Seeing land as a resource with particular qualities (similar to SRM). For LMGS the properties of what happens on the land surface and the processes which regulate this are core topics, whereas for SRM land is regarded as one of the economic resources, amongst other sub-soil resources and resources such as water, energy and food. Location, place, boundaries, legality and legitimacy are key conceptual elements of LMGS, rather than resource use and economic and environmental optimization. Both programs develop skills and knowledge in relying on multiple measurements, value systems and indicators to design and evaluate interventions, but the LMGS specifically focuses on the methods of spatial distribution and analysis of land interests, land claims

and land rights. Looking at land parcels and land division is therefore a fundamental object of research in LMGS, whereas this is not so in SRM.

- Compared to all other programs LMGS is much more internationally oriented. Understanding that land related matters do not stop at the borders of countries or regions, and knowing the variety of legal and institutional systems such an international orientation is much more crucial than construction oriented studies such as BI, UI and AR, and technology oriented studies such as GuG.
- Compared to the Bachelor BOLE the LMGS program provides a broader spectrum of land interventions and the embedding of geospatial technologies in land reform processes. Combining both legal regulatory frameworks with alternative soft governance solutions, such as systems of using legitimate land rights, voluntary guidelines of recognizing informal tenure and unplanned settlements, relying on social tenure models and rubber-booth land information systems.
- LMGS is transdisciplinary and oriented toward bringing different disciplines together for the creation of both suitable and politically acceptable solutions. This means that it is positioned at the interface of Civil, Environment and Geodetic Engineering, Landscape Architecture, Governance and Politics, and Spatial Planning and Management.

6 Program Structure

The degree program comprises 4 semesters and 120 CP in total. Within the first two semesters the students gain skills in land management sciences, in geospatial engineering sciences and in policy, governance, management and research sciences. In the third semester the students choose one of three areas of concentration and finalize their studies in the fourth semester by writing their master's thesis (see Figure 1).

The program is structured around three types of qualification:

1. Land management skills
2. Use of geospatial methods and techniques
3. Political and organizational aspects of land and geospatial interventions

This implies having clusters of modules which deal respectively with land management concepts and systems, geospatial science concepts and systems, governance, policy and management concepts, and systems related to land and geospatial interventions, and with research skills and tools. This need has been translated into a program design whereby each of those aspects is addressed in two semesters through required and elective modules.

1.		Land management sciences (required modules)	Geospatial engineering sciences (required modules)	Policy, governance, management and research sciences (elective modules)
2.				
3.	Area of concentration: (one out of three) <i>Mobility Window</i>	Systems of land use and land rights (elective modules)		
		Geospatial engineering for land, water and forestry management (elective modules)		
		Planning, policy and governance (elective modules)		
4.		Master thesis		
Key: grey: required modules light blue: elective modules from areas of concentration dark blue: final thesis				

Figure 1: Overview of the degree program's curriculum including mobility window in the 3rd semester

In the first semester two required modules of both land management sciences and geospatial engineering science, cover basics in each field. In the second semester there are also two required modules of each of these fields, dealing with the interacting (i.e. systems) parts of these two sciences and their professional usage. Furthermore, the first and second semester contain a variety of elective modules dealing with policy, governance and management science and research.

As land management interventions are always context-specific, students acquire skills to recognize and compare context, and to align interventions with this context. For example, in the required module property rights and land tenure systems, students are required to compare land tenure systems of different countries and to practice in class how to deal with these differences in case of a land transaction such as buying or selling property. Similarly, in the decision support systems module, students are required to translate needs and interest of different stakeholders into decision criteria. Thus, they are able to deal with context-specific situations.

The specific tools and techniques are especially addressed in the required geospatial science modules of the first two semesters. The measurement of property boundaries and their registration is practiced in the geodesy module. Similarly, the recognition of land boundaries and land use is addressed within the module of photogrammetry and remote sensing.

The cross-cultural aspects are trained throughout the degree program. Students are required to work together in multiple modules and to work with examples from different countries. Wherever possible, students are encouraged to complete the tasks in intercultural team settings. This will stimulate acceptance of different work perspectives and deriving non-standard results.

Finally, the conflict resolution skills and the policy design are addressed during the modules dealing with either spatial or environmental policy. Policy goals reflecting different belief systems are clustered using different techniques in classroom plenary sessions. With these clusters it is possible to visualize and map different interests and to design possible and feasible solutions.

The distinction between the semesters is designed such that the first semester deals especially with conveying the basic concepts of land management and geospatial engineering sciences whereas the second semester places the attention on designing and applying systems (legal, methodological and information systems). Systems thinking is needed to create the multi-disciplinary approaches and attitudes of these two sciences and can only be done after dealing with the basic concepts within the first semester. Conflict resolution competences are addressed in both the modules dealing with land management principles, where conflict resolution and social skills are an important aspect, and in the policy oriented modules, where reconciliation of different stakes is an important skill.

The pool of topics related to policy, governance, and management on the one hand, as well as the catalogue of research skills on the other hand, are broad and largely dependent on the students' interests and contexts of application. The program design therefore gives students the ability to choose and align their choices to their specific interests and needs. In practice this means that two thirds (40 CP) of the modules in the first two semesters are required modules, whereas one third (20 CP) can be chosen from a catalogue of modules related to research skills, planning, policy and governance sciences. The modules related specifically to land management are offered by the Chair of Land Management, the Geospatial modules are offered by the Chairs of the Geodesy cluster within the Department of Aerospace and Geodesy. The elective modules can be chosen from offers by at least three other departments including the Department of Civil, Geo and Environmental Engineering, the TUM School of Life Sciences Weihenstephan (WZW) and the School of Governance (GOV).

The third semester offers three areas of concentration based on the three core qualification types of LMGS each enabling students to conduct research. Within the areas of concentration, students are advised on which combinations of modules to select, based on their specific interests. In all cases where the choice differs from one of the recommended areas of concentration, the students' final selection of modules needs to be approved after consultation with a study mentor and/or degree program coordinator. Opting for modules offered by universities abroad is also included in the list of possibilities. The modules in the areas of concentration are clustered in specific catalogues which are updated each year and can be found on TUMonline. These clusters of elective modules allow students to deepen knowledge in a specific area of concentration, either focusing on systems of land rights and land use, on geospatial engineering for land, water and forestry management, or land

planning policy and governance. All elective modules of the third semester must sum up to at least 30 credits.

The third semester also offers a good opportunity for mobility options, see Figure 1. It is also possible to spend one semester at one of the program's partner universities, such as Renmin University in Beijing/China, Diponegoro University in Semarang/Indonesia, Université Jean Moulin Lyon 3 in Lyon/France and Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi/Ghana. Funding for such international semesters need to be acquired by the students themselves. Support in looking for scholarships is available at the TUM Center for Study and Teaching as well as the TUM Global & Alumni Office.

The master's thesis sums up the graduates' abilities to recognize a land management related issue, to analyze, evaluate and synthesize it making use of the methods and tools acquired through the program, in order to formulate an innovative solution specifically suited to for their case study.

Figures 2, 3 and 4 provide degree chart samples of three options for the degree program.

Semester	Modules						Credits
	Land management sciences		Geospatial engineering sciences		Policy, governance, management and research sciences		
1.	Land management (required) 5 CP	Real estate economics (required) 5 CP	Photogrammetry Remote sensing (required) 5 CP	Geodesy (required) 5 CP	Land management international theory and practice (elective) 5 CP	Ethics in science and technology (elective) 5 CP	30
2.	Property rights and land tenure systems (required) 5 CP	Land administration and land information systems 5 CP	Geoinformatics (required) 5 CP	Decision support systems (required) 5 CP	Scientific paper writing theory and practice (elective) 5 CP	Spatial planning and policy (elective) 5 CP	30
3.	Systems of land use and land rights Instruments of land mobilization theory and practice (elective) 5 CP	Landslides (elective) 5 CP	Summer school Nexus Water-Food-Energy (elective) 5 CP	Multi-level governance (elective) 5 CP	Big data and emerging countries (elective) 5 CP	International environmental policy and conflict resolution (elective) 5 CP	30
4.	Master Thesis 30 CP						30
Key: (exemplary)	dark blue: final thesis / internship light blue: elective modules grey: required modules						

Figure 2: Degree chart for a 4-semester LMGS master's degree program - area of concentration "**systems of land use and land rights**"

Semester	Modules						Credits	
	Land management sciences		Geospatial engineering sciences		Policy, governance, management and research sciences			
1.	Land management (required) 5 CP	Real estate economics (required) 5 CP	Photogrammetry Remote sensing (required) 5 CP	Geodesy (required) 5 CP	Scientific paper writing (elective) 5 CP	Spatial planning and policies (elective) 5 CP	30	
2.	Property rights and land tenure systems (required) 5 CP	Land administration and land information systems 5 CP	Geoinformatics (required) 5 CP	Decision support systems (required) 5 CP	Advanced GIS (elective) 5 CP	International Environmental Policy and Conflict Resolution (elective) 6 CP	30	
3.	Geospatial Engineering for land, water and forestry	Introduction to Earth System Science (elective) 5 CP	Signal processing and microwave remote sensing (elective) 5 CP	Remote Sensing selected chapters (elective) 5 CP	Advanced GIS II (elective) 5 CP	Big data and emerging countries (elective) 5 CP	Applied computer science (elective) 5 CP	30
4.	Master Thesis 30 CP						30	
Key: (exemplary)	dark blue: final thesis / internship light blue: elective modules grey: required modules							

Figure 3: Degree chart for a 4-semester LMGS master's degree program - area of concentration "**Geospatial Engineering for land, water, and forestry**"

Semester	Modules						Credits
	Land management sciences		Geospatial engineering sciences		Policy, governance, management and research sciences		
1.	Land management (required) 5 CP	Real estate economics (required) 5 CP	Photogrammetry Remote sensing (required) 5 CP	Geodesy (required) 5 CP	Spatial planning and policies (elective) 5 CP	Scientific paper writing (elective) 5 CP	30
2.	Property rights and land tenure systems (required) 5 CP	Land administration and land information systems 5 CP	Geoinformatics (required) 5 CP	Decision support systems (required) 5 CP	International Environmental Policy and Conflict Resolution (elective) 5 CP	Instruments of land mobilisation (elective) 5 CP	30
3.	Systems of planning, policy and governance	Multilevel governance (elective) 6 CP	Politics for rocket scientists (elective) 6 CP	Big data and emerging countries (elective) 6 CP	Land management and land policy (elective) 6 CP	Environment and climate transformation (elective) 6 CP	30
4.	Master Thesis 30 CP						30
Key: (exemplary)	dark blue: final thesis / internship light blue: elective modules grey: required modules						

Figure 4: Degree chart for a 4-semester LMGS master's degree program - area of concentration "**Systems of planning, policy and governance**"

7 Organization and Coordination

Day to day responsibilities are shared between program director (academic administrator for program design) and coordinator, hence most of the actions and decisions are consensually taken, ideally after consulting with other staff members and module coordinators in regular meetings, since communication and transparency are key elements in responsible positions. In case of disagreement regarding grading the Examination Board (Prüfungsausschuss) of the department of Aerospace and Geodesy decides.

The LMGS course is part of the system accreditation process at the entire TUM. This means that the LMGS has to adhere to the standards of TUM education. Part of this process is a yearly quality management circle. Hereby student evaluations are carried out, and a yearly course improvement plan is prepared.

A specific admission commission is formally responsible for the selection and admission process of students. The day-to-day evaluation of applications is executed by the course coordinator. The applications are assessed based on a combination of TUM admission criteria. In summary, these criteria include language, personal motivation and academic criteria.

The following administrative tasks will be carried out by:

- Central Study Guidance:

TUM Center for Study and Teaching (CST), Student Advisory Service

E-Mail: studium@tum.de; Phone: +49 (0)89 289 222 45

Offers information and guidance for: Prospective students and students (via Hotline/Service Desk)

- Academic Counselling and Program Coordination:

Chair of Land Management: Ms. Dr. Pamela Durán Díaz

E-Mail: pamela.duran@tum.de; Phone: +49 (0) 89 289 257 89

- Academic Programs Office for Department of Aerospace and Geodesy:

Ms. Isabelle Canchila Acuña

E-Mail: Isabelle.canchila@tum.de; Phone: +49 (0)89 289 - 55507

- Advice Study Abroad / Internationalization:

Central: TUM International Center; internationalcenter@tum.de

Decentral: Mr. Daniel Hartenstein, M.A.; daniel.hartenstein@tum.de

- TUM Gender Equality Officer:

Ms. Dr. Eva Sandmann,

E-Mail: sandmann@tum.de, Phone: +49 (0) 89 289 223 35

- Advice for barrier-free Study:

TUM Center for Study and Teaching (CST), Service desk for chronically ill and disabled students and prospective students, E-Mail: handicap@tum.de;

Phone: +49 (0)89 289 227 37

- Application and Immatriculation:

TUM Center for Study and Teaching (CST), Student Admission

E-Mail: studium@tum.de; Phone: +49(0)89 289 222 45

Offers information and guidance about: Application, Immatriculation, Student Card, Leave, Confirmation, Exmatriculation

- Aptitude Assessment (EV)

Central: TUM Center for Study and Teaching (CST), Student Admission

Decentral: Chair of Land Management, Ms. Dr. Pamela Durán Díaz

E-Mail: pamela.duran@tum.de; Phone: +49 (0)89 289 257 89

- Fees and Scholarships

TUM Center for Study and Teaching (CST), Semester fees and scholarships

beitragsmanagement@zv.tum.de

- Central Examination Affairs

TUM Center for Study and Teaching (CST), department Central Examination Affairs (Zentrale Prüfungsangelegenheiten)

Degree documents and certificates, certificates of completion of study

- Decentral Examination Administration at Department of Aerospace and Geodesy:

Mr. Daniel Hartenstein; E-Mail: Daniel.hartenstein@tum.de

- Examination Board

Mr. Prof. Dr. Florian Seitz (Chairman)

Mr. Prof. Dr. Roland Pail (Deputy Chairman)

Mr. Prof. Dr. Uwe Stilla

Mr. Prof. Dr. Urs Hugentobler

Mr. Prof. Dr. Thomas Kolbe

- Quality Management Study and Teaching

Central: TUM Center for Study and Teaching (CST);

Website: www.lehren.tum.de/startseite/team-hrs/

Decentral (QM Circle, Course Evaluations, Module Management): Dr. Robert Graner;

E-Mail: robert.graner@tum.de

Dean of Studies: Mr. Prof. Dr. Walter de Vries

8 Enhancement Measures

LMGS will be continuously advanced in relevant content by staying closely connected to the professional and scientific field of study through regular attendance at scientific and professional conferences (such as the yearly conference of the FIG (International Federation of Surveyors, EALD (European Academy of Land Use and Development) and the World Bank's Land and Poverty Conference amongst others. In addition, there are close professional links to the State Ministry of Food, Agriculture and Forestry in Bavaria and into the world.

The advancement of the LMGS program as compared to its predecessor Land Management and Land Tenure (LMLT) is in its breadth of subjects. LMGS represents a highly expanded and broadened subject area when compared to the previous LMLT program, for the following reasons:

- It introduces ways to enable students to gain skills for mapping, creating or analyzing data from several possible sources (e.g. demographic data at different levels, social media, smartphone photos, laser-captured data and satellite imagery) for location-specific decision making (e.g. for urban, rural or peri-urban development).
- It will expand the subjects of study beyond land into other subjects including climate and society, water, forest, hazards and resources; and strengthen society and environment relations in order to meet the goals of global development agenda. By choosing the area of concentration “geospatial engineering applications in land, water and forestry” one can choose modules which specifically fit this interest.
- It will contribute to producing Geospatial Scientist who can join the national/EU and international labor markets to answer the how-to aspects of applying geospatial technology (and skills) in various areas of development activities, including climate change mitigation and adaptation, land and natural resource management, emergency responses to environmental risks or disasters, transportation systems management, evidence-based planning, and geotechnical consulting tasks, to mention a few.
- It will strengthen existing inter-departmental collaborations in teaching and knowledge building with many other chairs at TUM because former peripheral courses in the LMLT program become the center-point of the LMGS program. In this regard, several knowledge areas – e.g. remote sensing, surveying, Global Positioning System) remotely sensed imagery, spatial analytics, Geographic Information System and decision-making skills using land/geospatial data for communication – will connect allow for inter- and cross-disciplinary collaborations with other chairs within TUM.

Alumni surveys of the LMLT in 2017 and 2018, inventorying the current positions and interests of alumni, and future needs indicated that:

- An international focus remains important, as most land-related problems do not stop at the borders and most types of solutions can be applied– in a modified and adapted form - to other contexts.
- International recognition and conformance to international standards of a Master's degree is crucial.

- A new program should find a meaningful combination between technical knowledge, based on new geospatial technologies, and socio-economic and political knowledge and skills. The LMGS program should be leading, unique and internationally competitive.

The newly designed LMGS meets these criteria.