Response to WP1 (Austria)

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Work package	Title
1	Analysis of natural disasters needed to be managed in Western Balkan region
Activity	Title
1.2	Survey of established practices in EU countries for NDRM

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1 Introduction

Information about established practices for natural disasters risk management in EU countries is indispensable for developing master curricula for risk management in Western Balkan regions. In work package 1.2 (WP 1.2) a collaborationbetween BOKU and all partners from EU countries is foreseen to dose the knowledge gap concerning natural disaster risk management. In the following chaptersinformation about natural disasters, analysis of risk management, survey of responsible institutes and analysis of education possibilities are documented for Austria.

2 Identification of natural disasters

Due to the fact that approximately two thirds of the Austrian national territory account for alpine regions, the greatest natural hazards are related to mountains. A distinction is drawn between hazards of alpine torrents (e.g.: debris flows or floods) and avalanches. Additionally, due to geological conditions, mass movements like landslides or rockfalls are repeatedly occurring in Austria. However, the highest damage potential is related to floods in large rivers, like Danube, Drava, Inn and Mur, crisscrossing the alpine valleys as well as the hilly and flat regions in the north-east of Austria (Interpraevent, 2009).
A ranking of natural disasters was defined by Rudolf-Miklau (2009) considering personal risk, damage risk and disaster potential.

Table 1: Ranking of natural disasters in Austria (Rudolf-Miklau, 2009)

Position	Type of natural disaster	Personal risk	Damage risk	Disaster potential
1.	Flood	Medium	Very high	Very high
2.	Avalanche	Very high	Medium	High
3.	Storm (hurricane)	Medium	High	Very high
4.	Earth quake	High	High	Medium
5.	Debris flow	High	Medium	Medium
6.	Landslide	High	Medium	Medium
7.	Rockslide	Medium	Medium	Medium
8.	Forest fire	Low	Medium	Medium
9.	Heavy rainfall (hail)	Low	Medium	Medium
10.	Rockfall	High	Low	Low
11.	Thunderstorm	High	Low	Low
12.	Snow pressure	Medium	Low	Low
13.	Drought	Low	Medium	Low
14.	Frost	Low	Low	Very low

2.1 Natural hazards of alpine torrents

A total number of around 17.800 torrential events have been reported since the year 600 AD, but it must be taken into account that usually only events with personal or material damage have been documented. In Figure 1 the spatial distribution of the documented events is shown,

whereby in general the majority of events took place in the alpine regions. A distinction between debris flows and floods is drawn in the following figure(Interpraevent, 2009).

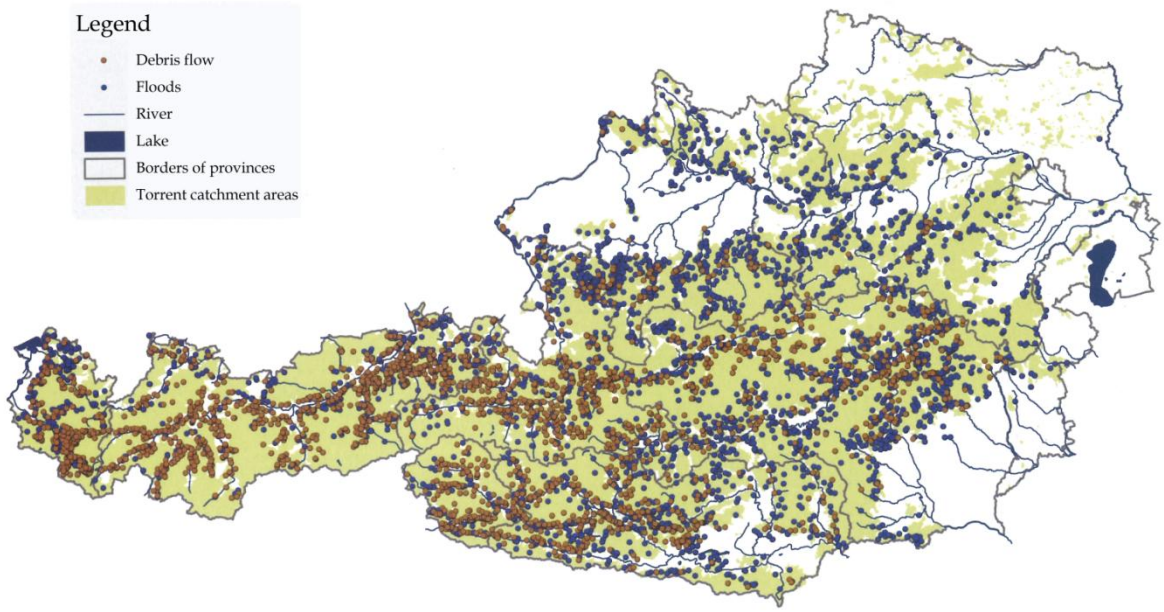

Figure 1: Spatial distribution of torrential events in Austria (Events of Lower Austria and Burgenland have not been collected completely.) (Interpraevent, 2009)

2.2 Avalanches

Due to the fact that several institutions collected information about avalanches over centuries and an overall database has not been set up so far, an accurate number of occurred avalanche disasters is not available. According to estimates around 5.000 to 10.000 disasters have been documented since the first in the year 1450. In Figure 2 the spatial distribution of avalanches, documented by the Federal Service of Torrent and Avalanches control, is shown (Interpraevent, 2009).

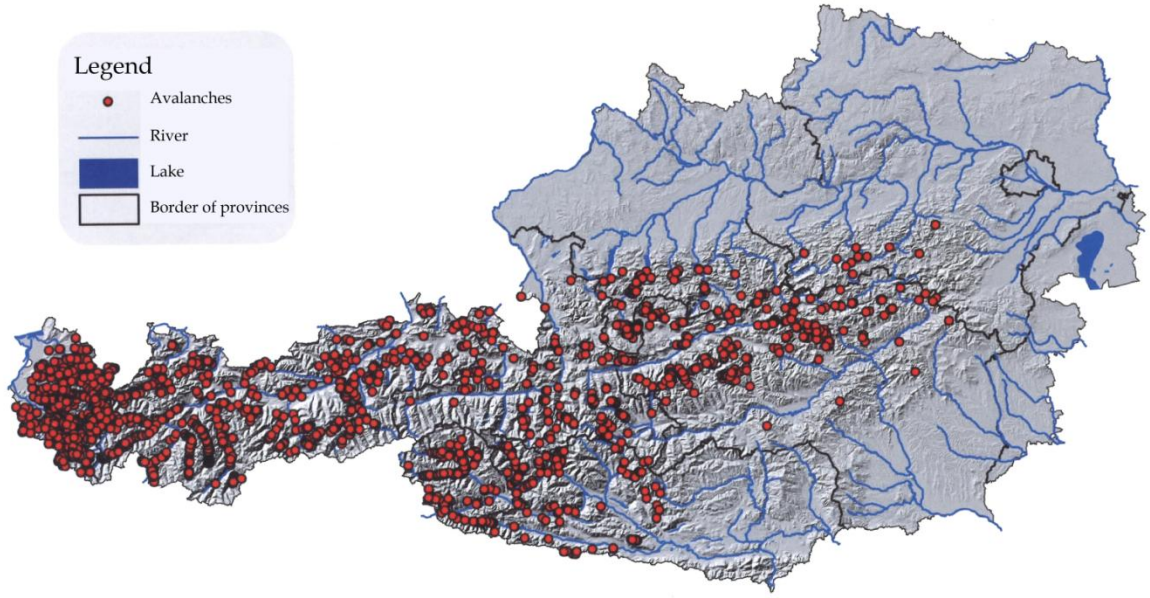

Figure 2: Spatial distribution of avalanches in Austria (Interpraevent, 2009)

2.3 Mass movements

A total number of around 25.000 gravitational mass movements have been reported in Austria so far. Unfortunately significant data gaps exist, due to the heterogeneous types and size of processes and difficulty of data acquisition. In Figure 3 the spatial distribution of the documented events is shown, whereby in some provinces (e.g. Province Tyrol) the data gaps are obvious (Interpraevent, 2009).

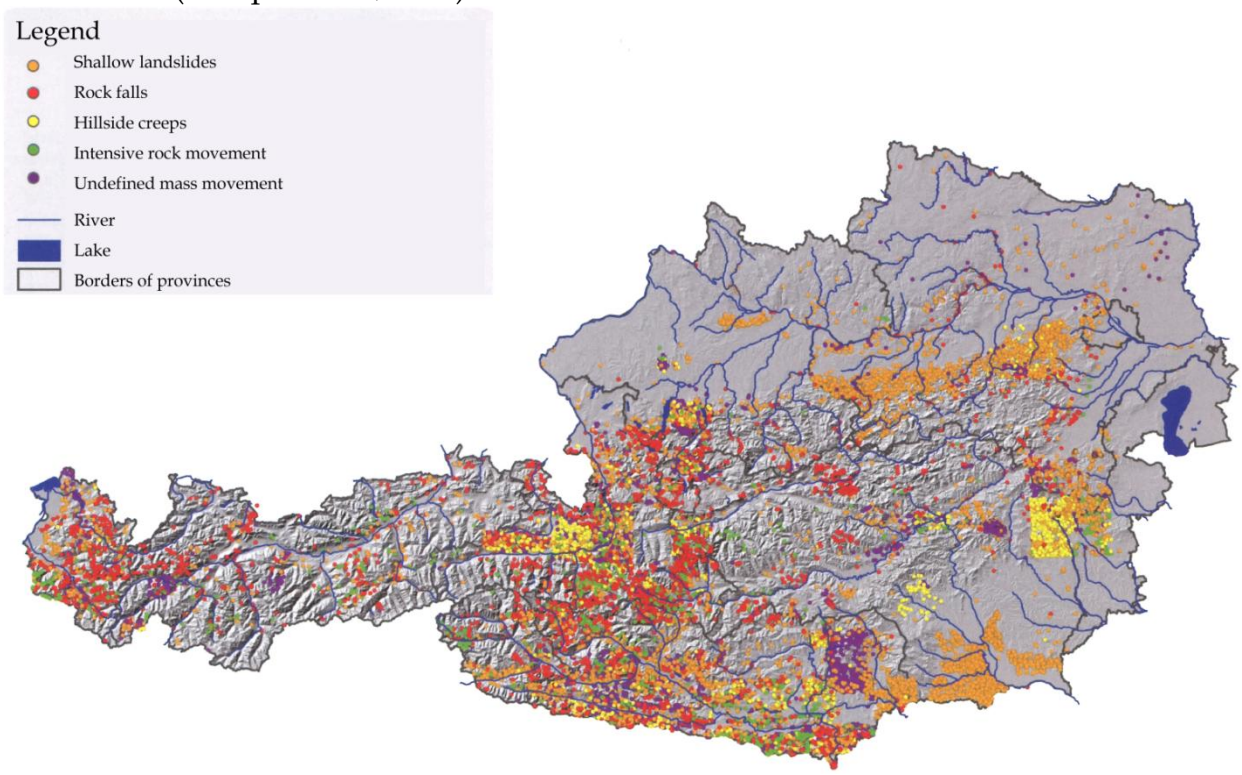

Figure 3: Spatial distribution of mass movements in Austria (Interpraevent, 2009)

2.4 Floods in large rivers

At large rivers substantial areas are affected in case of floods with high occurrence intervals. Therefore a quantitative description of floods at specific places does not necessarily indicate the actual hazards and risks. Thus, instead of overall numbers, a qualitative listing of a few serious floods in Austria occurred in the last years is used to point out the existing hazards related to floods.

Floods in August 2002

The natural disaster in August 2002 occurred due to two heavy rainfall episodes between 6th and 8th of August and 11th and 13th of August in the north-eastern provinces of Austria. Since the soil was saturated with water after the first precipitation event a majority of the second rainfall period was directly flushed downstream on the surface. The locations of different gauges at the Danube as well as the corresponding hydrographs are depicted in Figure 4. Due to the fact that design floods with occurrence intervals of 100 years (HQ_{100} of the Danube

~10.000 to 11.000 m³/s depending on the location) were exceeded in the Danube as well as in several tributaries, damage losses of around 3.2 billion Euros accrued (Habersack et al., 2004).

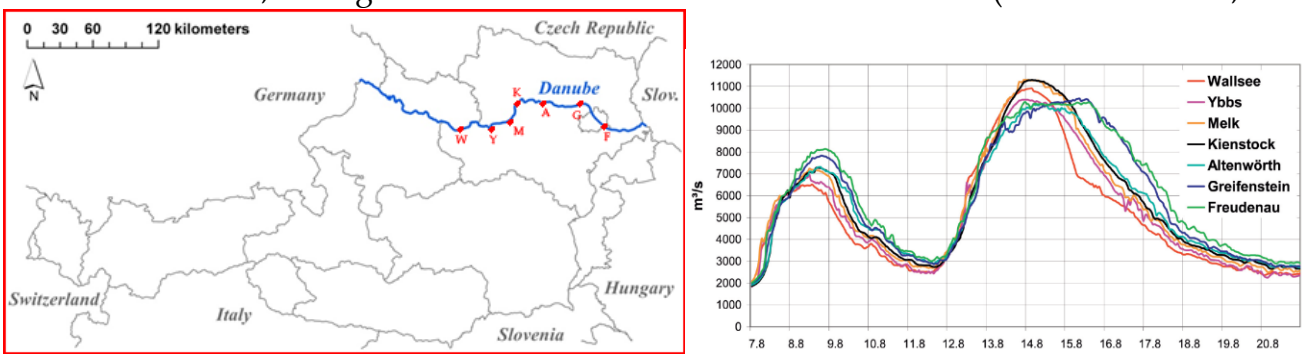

Figure 4: Overview of the gauges (Wallsee (W), Ybbs (Y), Melk (M), Kienstock (K), Altenwörth (A), Greifenstein (G), Freudenau (F)) and corresponding hydrograph of the gauges during the floods in August 2002 (Habersack et al., 2004)

Floods in August 2005

An active depression zone crossed Austria inAugust 2005 leading to enormous precipitation first in the south-east of Austria (Styria) and afterwards in the western provinces(Vorarlberg, Tyrol, and Salzburg). The total precipitation between 19th and 24th of August 2005 (Figure 5a) resulted in floods with returnperiods above 300 years (Figure 5b)for instance in the rivers Rosanna, Trisanna and Lech (BMLFUW, 2006a).

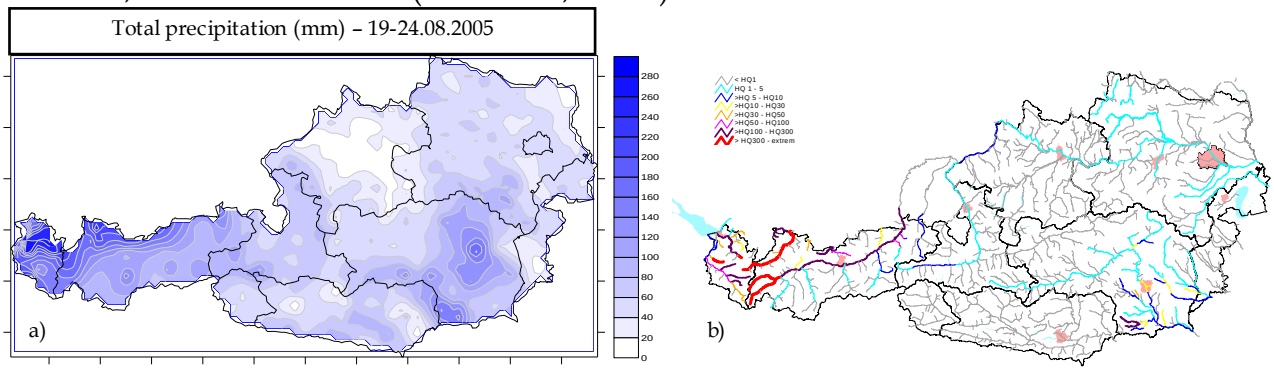

Figure 5: Natural disaster between 19th and 24th of August 2005: (a) Total precipitation (mm); (b) Return periods of floods (BMLFUW, 2006a)

Affected areas in the basin of river Trisanna (Tyrol Ischgl and Kappl) are shown in Figure 6 (BMLFUW, 2006b).

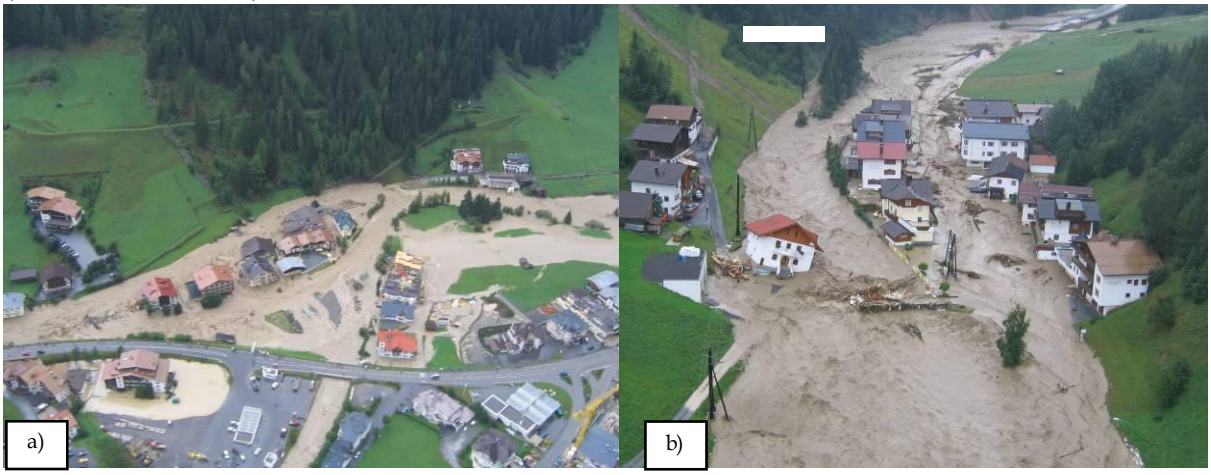

Figure 6: Natural disaster between 19th and 24th of August 2005: (a) River: Trisanna, Village: Ischgl; (b) River: Trisanna, Village: Kappl (BMLFUW, 2006b)

Floods in June 2013

In June 2013 enormous precipitation led to floods in large areas of Austria. According to estimates around 866 million Euros in losses were caused by these natural disasters. The occurrence intervals in different river basins are depicted in Figure 7. River basins in the north of the Alps were strongly affected and the water masses of these rivers discharged into the Danube resulting in a more than 100-years flood in the largest river of Austria(BMLFUW, 2015).

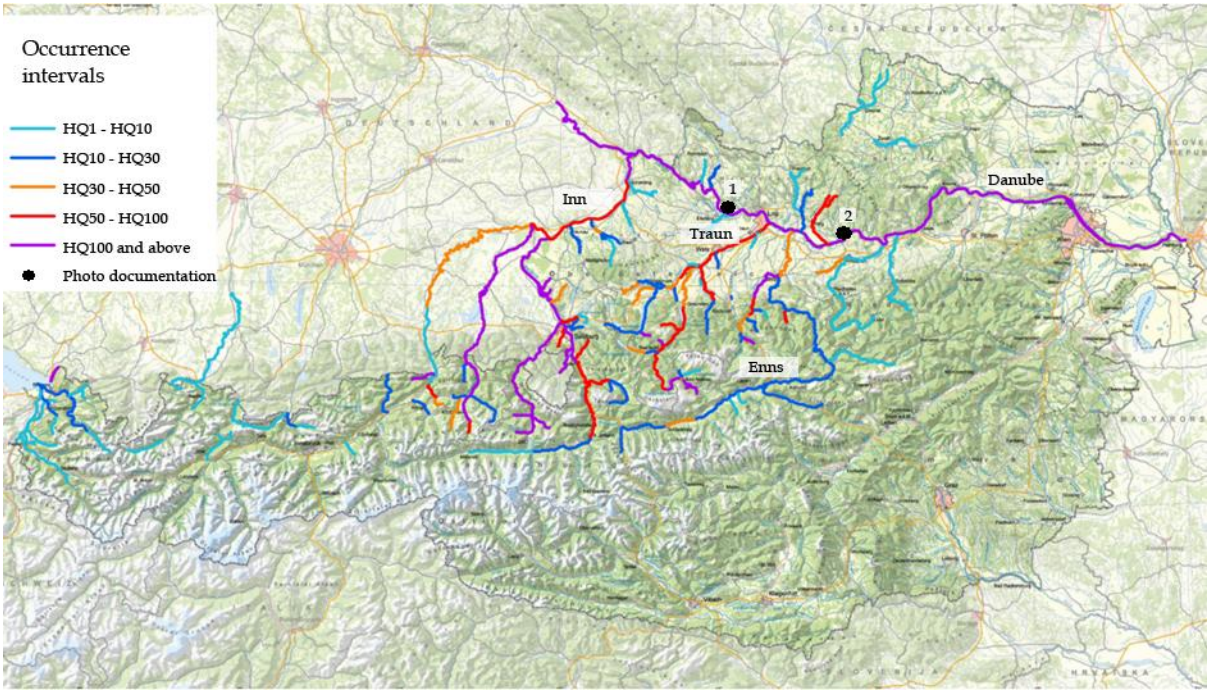

Figure 7: Overview of the recurrence intervals during the floods in June 2013 in Austria (BMLFUW, 2015)

The following photo documentation (Figure 8) shows the effects of this serious flood in rural areas and is referenced in Figure 7 at position 1.

Figure 8: Areal image of municipality Goldwörth during the floods in June 2013 (BMLFUW, 2015)

Due to the enormous losses during the flood in the year 2002 a lot of protection measures have been installed afterwards. The following photo documentation (Figure 9) shows the effects of performing measures during the serious flood in the year 2013 and is referenced in Figure 7 at position 2.

Figure 9: Mobile flood protection measures in municipality Grein during the flood in June 2013 (BMLFUW, 2015)

3 Analysis ofestablished risk management strategies

The management strategies of natural disasters have changed over time in Austria. Until the Middle Ages a fatalistic attitude has shaped the inhabitants of the Alps resulting in a conviction to be at mercy of natural forces. However, individual protection structures have been implemented over time,coping with natural disasters. The rational ideologies in the 19th century led to technical, systematic strategies resulting in a national prevention system.Since the 1980s an integrated natural hazard managementhas been developed. The main issue of this strategy is an integrated treatment of natural hazards including sustainable coping, rebuilding and prevention measures (Rudolf-Miklau, 2009).
The individual parts of the integrated natural hazard management are summarized in the risk circle (Figure 10) and are described in the following sub-chapters (according to Rudolf-Miklau, 2009; Habersack et al., 2004).

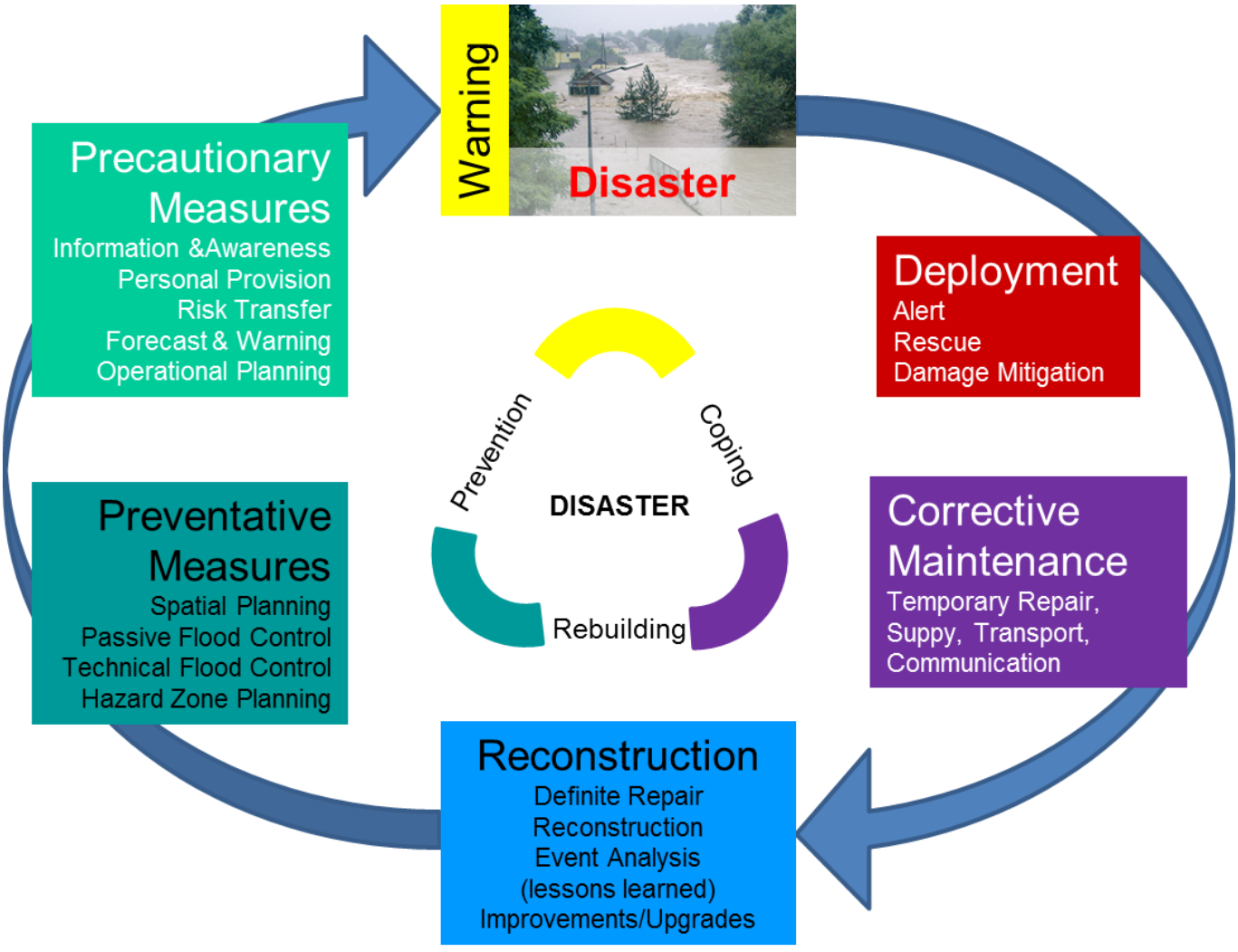

Figure 10: Integrated natural hazard management in Austria – Risk circle (according to Habersack et al., 2004)

The initial event of this risk circle is a disaster.In between two disasters people have to cope with the effects of the first disaster and afterwards they have the opportunity to learn from the experiences to be prepared for upcoming disasters.

3.1 Deployment

Immediately after the natural disaster urgent measures have to be implemented. Responsible authorities (e.g. Police, fire brigade, Red Cross, Austrian Armed Forces, etc.) will be alerted in case of emergency to man and property or in case of danger to medical, technical and public safety. Additionally, emergency measures are implemented to mitigate damages. Besides the mentioned national authorities a voluntary aid organisation called "Team Österreich" has been established by the radio station "Hitradio Ö3" and the Red Cross in the year 2007. In the meantime around 50.000 volunteers joined "Team Österreich", who will be informed in case of emergency and support the national authorities (e.g. filling of sandbags, shovelling snow, clean-up exercises, childcare, etc.).

Figure 11: Emergency measures – Filling of sandbags by "Team Österreich" (Hitradio Ö3)

3.2 Corrective Maintenance

In the course of corrective maintenance necessary infrastructure (e.g. bridges (Figure 12), streets, power and water supply, telecommunication network, etc.) will be temporarily repaired to rehabilitate standard processes and humanitarian and financial support will be provided to affected persons.During and after the event information will be collectedincluding mapping, marks on buildings, flow paths, damage reports, photos, etc.

Figure 12: Corrective Maintenance – Temporary repair of a bridge (Bundesheer, Moser, 2009)

3.3 Reconstruction

This phase includes the definitive reconstruction of buildings, roads and infrastructure. Based on the available disaster documentations analyses and reflections of the natural disaster will be done. Committed mistakes will be evaluated and knowledge gaps will be shown to draw conclusions ("lessons learned") and learn for upcoming events. The gained information will be further used for the improvement or upgrade of future protection measures or strategies.

3.4 Preventive Measures

The main goal of preventive measures is the defense of natural disasters by reducing the intensity and frequency of these events. Specific laws, scientific research, monitoring, preventive planning, engineering and ecological measures as well as protection of buildings counts towards these measures. The natural hazard overview and risk assessment (HORA, www.hora.gv.at(BMLFUW, 2017a), Figure 13) is an appropriate example for preventive measures against natural disasters and serves as basis for spatial planning in Austria.

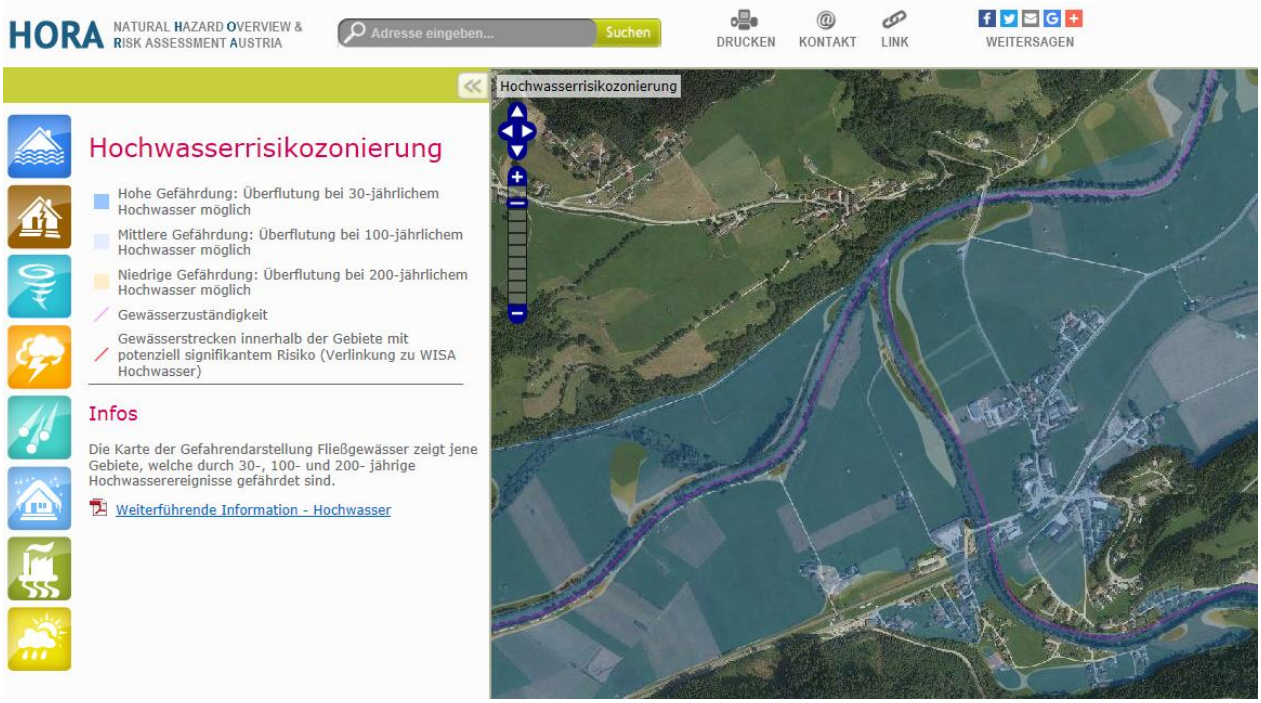

Figure 13: Preventive Measures – Natural hazard overview and risk assessment (HORA, www.hora.gv.at)

A few preventive measures related to floods are exemplarily described due to the significant risk of these events in Austria. According to the EU Floods Directive a preliminary flood risk assessment (until 2011) andflood hazard as well as flood risk maps (until 2013)have been prepared.The flood hazard maps (Figure 14) and the flood risk maps (Figure 15) are available in a scale of 1:25.000 on the following webpage http://wisa.bmlfuw.gv.at/ (BMLFUW, 2017b).

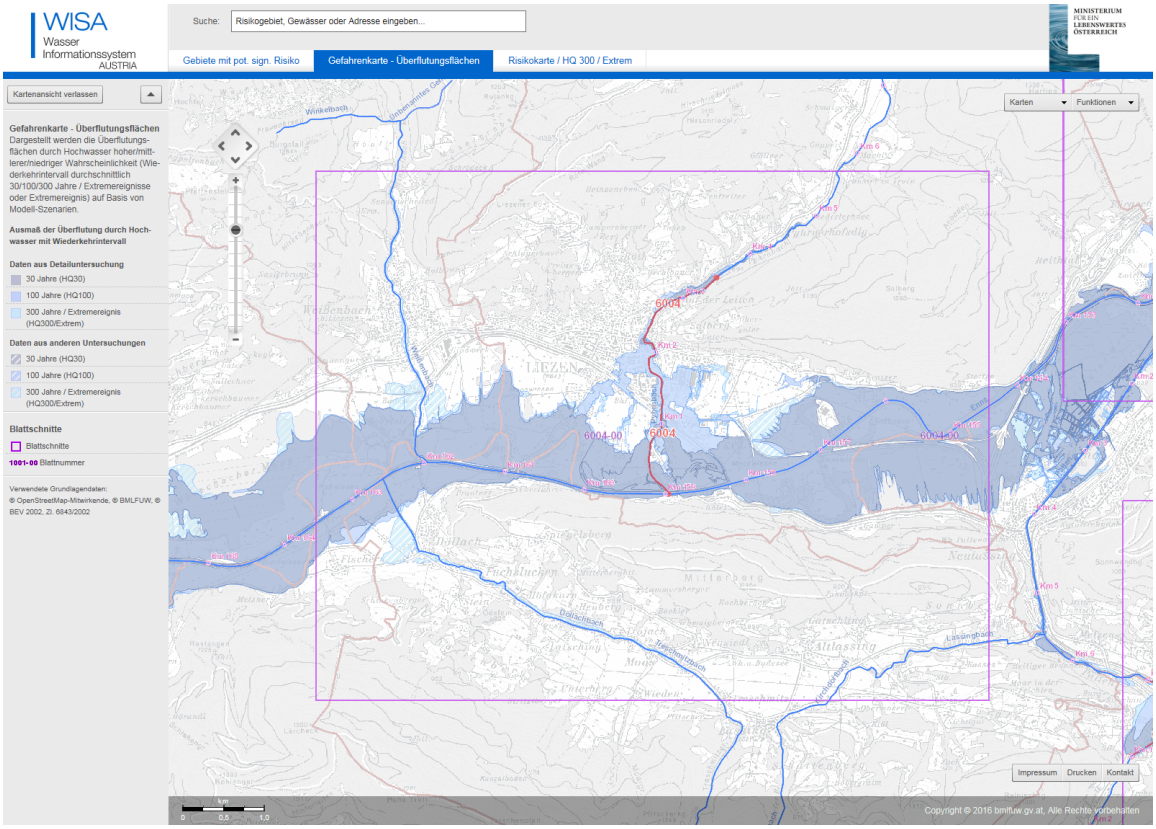

Figure 14:Preventive Measures – Flood hazard map (HORA, http://wisa.bmlfuw.gv.at/)

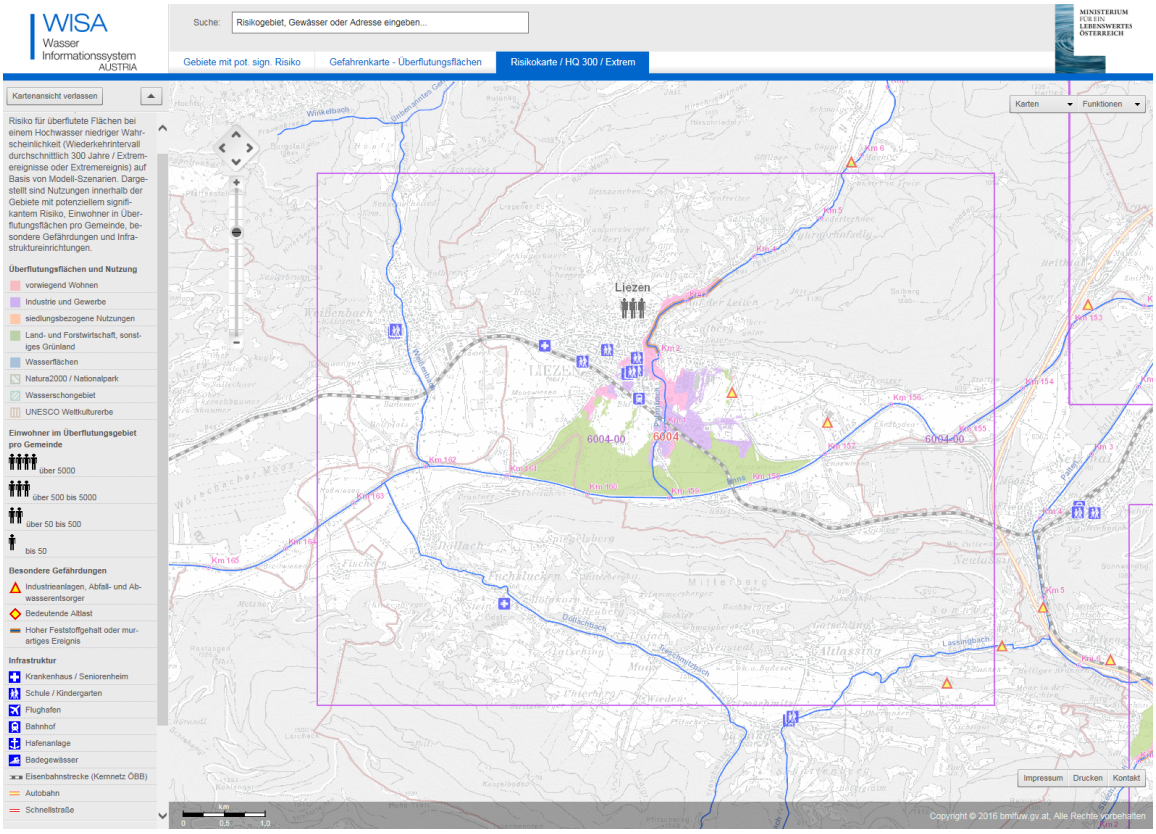

Figure 15:Preventive Measures – Flood risk map (HORA, http://wisa.bmlfuw.gv.at/)

Based on the assessment and the existing maps a national flood risk management plan – RMP (BMLFUW, 2016) has been developed until 2015. In this national flood risk management plan appropriate objectives to reduce the risk as well as measures and their ranking to reach these targets are defined. The fundamental framework of this "RMP" is based on the risk circle and includes coping, rebuilding and preventing measures.

3.5 Precautionary measures

Precautionary measures serve as preparation for coping with upcoming natural disasters. Public information and awareness as well as risk transfer (e.g. insurances)count towards these measures. Efforts to promote personal provisions (e.g. incentives) are also included in precautionary measures.
The second main part is related to measures needed to be taken shortly before a natural disaster. Weather forecast and early warning systems provide information for disaster control and emergency services, which use the generated data for operational planning.

4 Analysis of responsible institutes

In the existing organizational structures of the national natural hazards management in Austria, the tension between "central control" and "local action" becomes apparent as three prerequisites must be fulfilled simultaneously for optimal coping, rebuilding and prevention of natural catastrophes: Regional presence, immediate availability of necessary resources and coordinated action by all stakeholders.
The balancing act between "central control" and "local action" is subject to the national organizational principles, the federal principles and subsidiarity principles. Additionally to the governmental organization, private institutes (insurances, associations, media, citizens, etc.) contribute to the natural hazards management.
A successful, integrated risk management has to consider the mentioned boundary conditions and distribute responsibilities and tasks in all conscience.

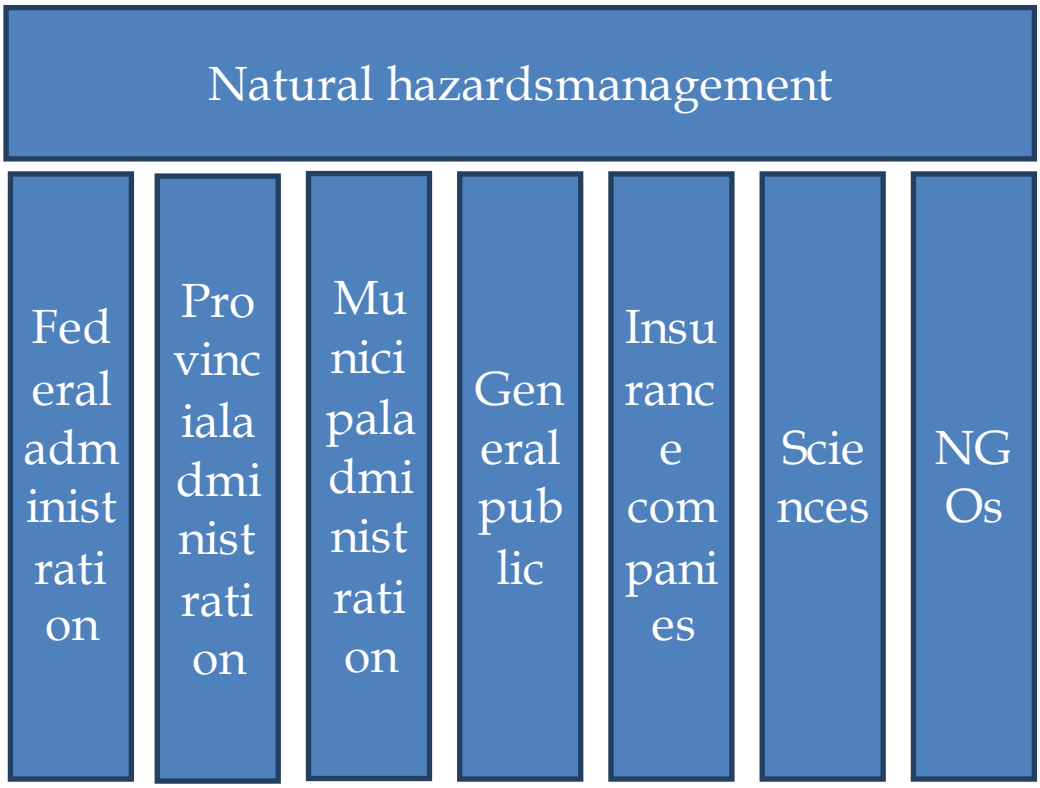

Figure 16: Organizational structure of natural hazards management in Austria

4.1 Federal administration

The federal administration focuses on prevention measures in the natural hazards management including the consideration of Water Act, forest law, traffic law and public health care.

Related federal authorities are listed below:

- Railway agency
- Cableway agency

- Highway agency
- Security policy
- Health care agency

Related public-sector institutions and special services are listed below:

- Central Institution for Meteorology and Geodynamics (ZAMG) www.zamg.ac.at
- Federal Geological Office (GBA) www.geologie.ac.at
- Central Hydrographical Bureau www.wassernet.at
- Federal Agency for Water Management (BAW) www.baw.at
- Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW) http://bfw.ac.at
- Forest Engineering Service in Torrent and Avalanche Control (WLV) www.die-wildbach.at
- Federal Water Engineering Administration (BWV)
- Federal Waterway Administration (via donau) www.via-donau.org
- Civil Defense, Civil Protection, and Disaster Management (BWZ) http://www.bmi.gv.at/cms/BMI_Zivilschutz_en/

All mentioned authorities, public-sector institutions and special services are governed by different federal Ministries:

- Ministry of Finance (BMF)
- Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW)
- Ministry for Transport, Innovation and Technology (BMVIT)
- Ministry for the Interior (BMI), Ministry of National Defence and Sport (BMLVS)
- Ministry of Science, Research and Economy (BMWFW)
- Ministry of Labour, Social Affairs and Consumer Protection (BMASK)
- Ministry for Europe, Integration and Foreign Affairs (BMEIA)

4.2 Provincial administration

The provincial administration focuses on coping measures in the natural hazards management including spatial planning, disaster management and fire brigades, which are enshrined in provincial laws.Additionally, official tasks related to federal laws (e.g. Water Act, forest law, environmental impact assessment, etc.) are executed by provincial administration.

Related provincial authorities are listed below:

- Forestry authority
- Water authority

- Environmental authority
- Nature Conservation authority
- Regional Planning authority
- Transport authority
- Disaster Control authority

Related public-sector institutions and special services are listed below and are available in each of the nine Austrian provinces:

- Hydrographic Services (HD)
- Federal Water Engineering Administration (BWV) (branch office in each province)
- Forest Services (LFD)
- Provincial Road Administration
- Provincial Geology
- Provincial Warning Centre (LWZ)
- Avalanche Warning Service (LWD)

Information on all mentioned authorities, public-sector institutions and special services are available on the official websites of the nine Austrian provinces.

4.3 Municipal administration

The municipal administration focuses on the execution of federal and provincial laws related to measures in the municipal district including traffic police, fire brigade, building inspection and health care.

Related municipal authorities are listed below:

- Building authority

Related public-sector institutions and special services are listed below and are available in each of the 2100 municipalities in Austria:

- Mayor
- Avalanche Commission

Information on mentioned authorities, public-sector institutions and special services are available on the official websites of the municipalities.

4.4 General public

The most important services of the population in connection with natural hazards are personal provision and behavioral provision as well as self-help in emergency and disaster situations (Rudolf-Miklau, 2009).

4.5 Media

Media are important multipliers of knowledge about natural hazards and are used to spread information during disasters. The dissemination of calls and announcements by federal and provincial authorities in case of a disaster is foreseen by law (Media Act and ORF Act) (Rudolf-Miklau, 2009).

4.6 Insurance companies

Private insurance companies provide an opportunity for the risk transfer of natural catastrophes. However, this opportunity has rarely been established in Austria, due to the fact that federal disaster funds are available in case of emergency. Exceptions here are storm and hail insurances, which are common in Austria (Rudolf-Miklau, 2009).

4.7 Science and standardisation institutes

Due to the high relevance of natural disasters a lot of public and private scientific research institutes focus on this important and interdisciplinary topic in Austria. The University of Natural Resources and Life Sciences, Vienna (BOKU), Vienna University of Technology (TU Wien), Graz University of Technology (TU Graz) and University of Innsbruck (UIBK) are prominent representatives of research institutes. In cooperation with federal and provincial authorities projects are managed to clarify outstanding scientific issues.
In addition, standards and guidelines related to natural disasters are developed by federal agencies(Rudolf-Miklau, 2009).

4.8 NGOs

Non-governmental organizations (NGO), which are working in the field of environmental protection, concentrate on research on natural disasters, due to their high impact on the environment. Prominent representatives of NGOs in Austria are CIPRA, Austrian Alpine Association (ÖAV), WWF, Greenpeace and Austrian League of Nature Conservation(Rudolf-Miklau, 2009).

5 Assessment of risk management aspects

5.1 Advantages

Integrated natural hazard management

The integrated approach of risk management including coping, rebuilding and prevention measures offers several benefits for Austrian inhabitants. This approach provides comprehensive services for parties concerned including affected persons, companies and municipalities. The compliance with the risk circle ensures a sustainable treatment of natural disasters.

Emergency services

The cooperation between emergency services in case of a natural disaster works very well. A large contribution to successful operations is based on volunteers, who cooperate with national authorities and support them in case of accidents. Besides voluntary aid organisations like "Team Austria" many Austrian inhabitants are voluntary members of fire brigades and the Red Cross. All these authorities offer trainings and educational courses to be prepared for natural disasters. The head and management of necessary urgent services is often task of professionals of the Austrian Armed Forces or fire brigades, who are well educated and prepared for state of emergencies. The mentioned cooperation has been improved over years, which has led to a significant decrease of fatalities due to natural disasters.

5.2 Disadvantages

Awareness of land use

Since the 1980s an integrated natural hazard management has been developed aiming for a lifestyle adjustment in order to cope with natural hazards. This approach should be pursued due to global climate change leading to an imminent increase of natural hazards.
Nevertheless this strategy contrasts with the long-lasting approach of defending natural hazards by engineering measures. Consequently constructions are built in potential vulnerable areas leading to unsustainable land use and land sealing. The development of land use in Austria is shown in Figure 17, which was around 14 ha/day in the year 2015, but the target value for sustainable development is 2.5 ha/day. The gap of around 11.5 ha/day is an indicator for a lack of awareness of the importance of potential vulnerable areas (Umweltbundesamt, 2016).

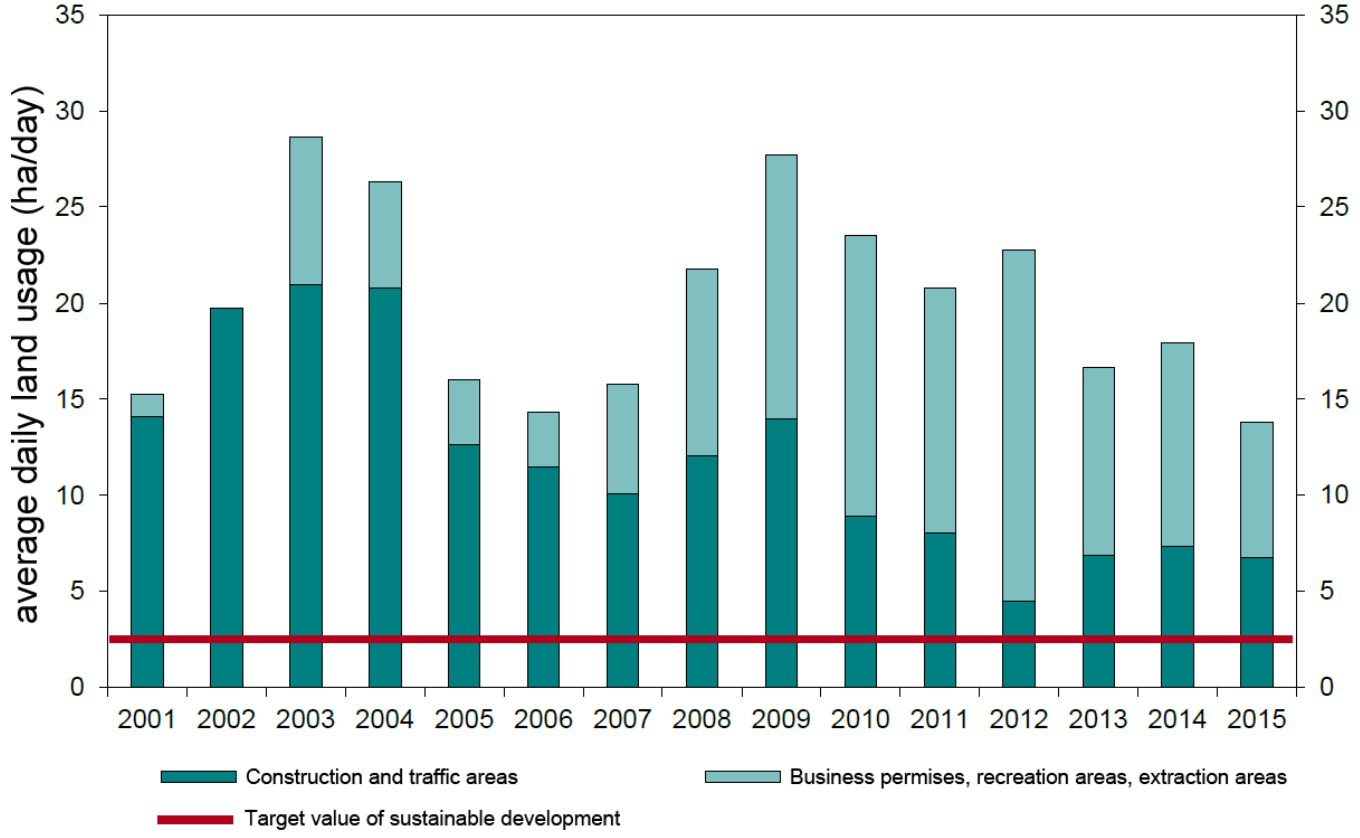

Figure 17: Average daily land usage in ha/day in Austria (modified from Umweltbundesamt, 2016)

Organizational structure of natural hazards management

The federal administration focuses on prevention measures in risk management, which are different depending on the natural hazards. Due to this fact different administrations are responsible employing specialists of various scientific areas. The federal organization "WLV" (Austrian Federal Torrent and Avalanche Control) focuses on natural hazards in alpine regions including mass movements, debris flows, rock falls, etc. and the federal organization "BWV" (Austrian Federal Water Engineering Administration) deals with risk management in large rivers. However, the discrepancy is evident in successive or overlapping areas. The influence of tributaries on large rivers is important and therefore preventive measures have to be coordinated and information in case of emergency has to be distributed among the mentioned organizations.

Similar issues are discernible between federal and provincial administrations as well as between different provincial administrations. The Austrian national territory is subdivided in nine different provinces leading to nine administrations and their corresponding legal bases. The various lawsparticularly affect spatial planning issues (controlled by federal administrations) resulting in different regulations in case of vulnerable areas.

An improved cooperation between the different authorities as well as a standardization of legal bases is therefore desirable.

5.3 Knowledge gaps

Scientific research

Data acquisition has a long tradition in Austria and forms a solid base for scientific research. Nevertheless an expansion of gauges related to different research areas (e.g. permafrost, sediment transport, etc.) might close the existing knowledge gaps and improve the physical process understandings. Based on the new findings the existing risk management strategies might be improved to be prepared for future challenges like climate change.

Public awareness

In the Austrian general population there exists often a lack of understanding of natural hazards and their impacts due to the existing prevention measures. Only a small percentageis aware of residual risks and the need of individual responsibility. In the scope of information and participation events the public awareness should be increased to be better prepared in case of natural disasters.

6 Analysis of EU master curricula

In Austria a few master's degree programmes related to natural disaster risk management are available at different universities.

6.1 Alpine Natural Dangers / Watershed Regulation (AND)

In the master's degree programme "Alpine Natural Dangers / Watershed Regulation" of the University of Natural Resources and Life Sciences Vienna (BOKU, 2015) the students acquire the necessary knowledge and skills for a responsible handling of hazards in alpine regions. In order to achieve the educational objectives, the program is oriented towards the cycle of "integral risk management" including sustainable coping, rebuilding and prevention measures. In addition to scientific and technical courses, questions of natural hazard legislation, spatial planning, disaster prevention and management are an essential part of the study program.

Occupational fields

Graduates of the master's degree programme "Alpine Natural Dangers / Watershed Regulation" are prepared for employments in the following fields of activities:

- Evaluation and analysis of hazards and mass movements in alpine regions
- Prevention of alpine natural hazards
- Integrated river basin management
- Risk prevention
- Disaster management

3-pillar-principle

The characteristic of each master's degree programme at the University of Natural Resources and Life Sciences is the "3-pillar-principle", which ensures a minimum percentage of 15% of courses in each of the following scientific areas:

- Engineering sciences
- Natural sciences
- Economic, social and legal sciences

Scope and classification

In the scope of this master's degree programme courses in the extent of 120 ECTS have to be taken. The courses are subdivided into the following classification:

- Compulsory courses: 22 ECTS
- Master thesis: 30 ECTS
- Elective courses: 50 ECTS
- Free elective courses: 18 ECTS

Due to the fact that the entire master's degree programme is related to risk management, all potential courses are listed in Table 2.

Table 2: Courses of the master's degree programme "Alpine Natural Dangers / Watershed Regulation"

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Compulsory courses					
Hydrological hazards - analysis and assessment	SE	AND	Hübl J, Bernhardt M, Kaitna R	Institute of Mountain Risk Engineering (IAN)	3
Hydrological hazards - mitigation measures	L	AND	Hübl J, Habersack H, Schober B	Institute of Mountain Risk Engineering (IAN)	3
Runoff formation in torrential headwater basins	SE	AND	Holzmann H, Hübl J	Institute of Water Management, Hydrology and Hydraulic Engineering (IWHW)	2
Snow and avalanche hazards - analysis and evaluation	L	AND	Reiweger I (Heil K), Fischer J (Eberl A)	Institute of Mountain Risk Engineering (IAN)	3
Technical protection measures: avalanches	L	AND	Sauermoser S	Institute of Mountain Risk Engineering (IAN)	3
Landslide hazards	SE	AND	Mergili M, Straka W, Zangerl C	Institute of Applied Geology (IAG)	3
Hazards due to mass movements - rockfall	L	AND	Brauner M	Institute of Applied Geology (IAG)	3
Master's thesis seminar	SE	AND	Bergmeister K, Drexel A, Fiebig M, Florineth F, Fuchs S, Hübl J, Kaitna R, etc.	Institute of Mountain Risk Engineering (IAN)	2
Elective courses					
Silviculture and forest protection	L	AND	Lexer M, Vacik H, Netherer S	Institute of Silviculture (WALDBAU)	5
Mountain forest ecosystems	SE	AND	Katzensteiner K	Institute of Forest Ecology (IFE)	3
Design of protection works	L	AND	Suda J	Institute of Structural Engineering (IKI)	4
Fundamentals of geotechnical engineering	L	AND	Wu W	Institute of Geotechnical Engineering (IGT)	4
Environmental aspects in the flood protection	L	AND	Merwald I	Institute of Mountain Risk Engineering (IAN)	3
Aquatic ecology and river morphology	L	AND	Hauer C, Seliger C	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	3
Construction methods and management for barrier structures	SE	AND	Wehrmann H	Institute of Structural Engineering (IKI)	2
Structural maintenaince and monitoring	L	AND	Strauss A, Suda J	Institute of Structural Engineering (IKI)	2
Structural and objective based protection measures	L	AND	Hübl J, Strauss A	Institute of Structural Engineering (IKI)	4
Afforestation and forest protection near the timberline	L	AND	Halmschlager E, Klumpp R	Institute of Forest Entomology, Forest Pathology and Forest Protection (IFFF)	3
Soil bioengineering techniques	L	AND	Rauch J	Institute of Soil Bioengineering and Landscape Construction (IBLB)	2
Management of protective forests	L	AND	Hasenauer H, Seidl R	Institute of Silviculture (WALDBAU)	3
Wildlife ecology in protective and in selectively harvested forest stands	L	AND	Reimoser F	Institute of Wildlife Biology and Game Management (IWJ)	1.5

Spatial planning in alpine areas	L	AND	Seher W, Weiß G	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	2
Natural danger law	L	AND	Wagner E	Institute of Law	2
Vulnerability and risk management	SE	AND	Fuchs S	Institute of Mountain Risk Engineering (IAN)	2.5
Introduction to natural hazard management	L	AND	Rudolf-Miklau F	Institute of Mountain Risk Engineering (IAN)	1.5
Civil protection	L	AND	Kaiser P	Institute of Mountain Risk Engineering (IAN)	1.5
Communicaton, information and participation	L	AND	Volgger S	Institute of Mountain Risk Engineering (IAN)	3
Forecasting and warning systems	L	AND	Hübl J	Institute of Mountain Risk Engineering (IAN)	1.5
Event documentation and damage analysis	L	AND	Hübl J	Institute of Mountain Risk Engineering (IAN)	1.5
Disaster management and emergency services	L	AND	Kreuzer S (Mayr B)	Institute of Mountain Risk Engineering (IAN)	1.5
Politics of natural hazards and risk governance	SE	AND	Rudolf-Miklau F	Institute of Mountain Risk Engineering (IAN)	1.5
Damage adjustment	L	AND	Holub M	Institute of Mountain Risk Engineering (IAN)	1.5
Watershed management	P	AND	Hübl J (Nagl G), Neumann M	Institute of Mountain Risk Engineering (IAN)	6
Dynamics of geophysical flows	SE	AND	Kaitna R	Institute of Mountain Risk Engineering (IAN)	3
Scenario development and analysis	L	AND	Mazzorana B	Institute of Mountain Risk Engineering (IAN)	2
Simulation models in natural hazards analysis	P	AND	Braito S, Hübl J, Scheidl C	Institute of Mountain Risk Engineering (IAN)	3
Road network planning	SE	AND	Pertlik E (Holzfeind T, Santner C), Holzleitner F, Kühmaier M	Institute of Forest Engineering (FT)	5
Harvesting systems	SE	AND	Holzleitner F (Gruber P), Kanzian C	Institute of Forest Engineering (FT)	3

6.2 Civil Engineering and Water Management (CEWM)

The master's degree programme "Civil Engineering and Water Management" of the University of Natural Resources and Life Sciences, Vienna (BOKU, 2016) leads the students into the knowledge and working methods of applied natural sciences and their engineering applications. Graduates have a well-founded basic knowledge and a comprehensive understanding of sustainable use of natural resources. In addition, the ability of networked thinking in designing, planning, building and maintaining processes will be supported.

Occupational fields

Graduates of the master's degree programme "Civil Engineering and Water Management" are prepared for employment in the following fields of activities:

- Water management
- Land management, construction engineering and management
- Traffic and infrastructure management

- Waste management
- Geoinformation
- Risk management

3-pillar-principle

The characteristic of each master's degree programme at the University of Natural Resources and Life Sciences is the "3-pillar-principle", which ensures a minimum percentage of 15% of courses in each of the following scientific areas:

- Engineering sciences
- Natural sciences
- Economic, social and legal sciences

Scope and classification

In the scope of this master's degree programme courses in the extent of 120 ECTS have to be taken. The courses are subdivided into the following classification:

- Compulsory courses: 29 ECTS
- Master thesis: 30 ECTS
- Elective courses: 48 ECTS
- Free elective courses: 13 ECTS

Within the scope of elective courses four to six out of 13 subjects (Traffic and Transport planning, Geo Data Management, Land Management and Spatial Development, Risk Management and Resource Protection, Hydrology and Water Management, Hydraulic Engineering and River Management, Structural Design and Construction Industry, Structural Safety and Reliability Assessment, Aquatic Ecology, Sanitary and Industrial Water Management,Soil Water Management, Geotechnics and Applied Geology, Waste Management) have to be selected with at least 8 ECTS each. The subject of Risk Management and Resource Protection, including courses related to natural risk management, and all essential compulsory courses are listed in Table 3.

Table 3Compulsory courses and selected elective courses of the master's degree programme "Civil Engineering and Water Management"

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Compulsory courses					
Construction and plane load-bearing structures	L	CEWM	Bergmeister K (Felderer C), Schwenn M (Lanik S), Stierschneider E (Mitterlehner S), Strieder E, Zeman O	Institute of Structural Engineering (IKI)	4
Applied geotechnical engineering	L	CEWM	Wu W (Brandmaier M), Acharya M	Institute of Geotechnical Engineering (IGT)	4
Hydromechanics	L	CEWM	Tritthart M (Brandmaier M), Nolz R (Wildt D)	Institute of Hydraulics and Rural Water Management (IHLW)	4
Special administrative law for civil engineering	SE	CEWM	Mittermüller B (Fürmann M), Werinos-Sydow S	Institute of Law	4
Strategic planning, desicion support, and mediation	SE	CEWM	Hössinger R (Wiesmann T), Aschauer F	Institute for Transport Studies (IVe)	3
Natural hazards	L	CEWM	Kaitna R	Institute of Mountain Risk Engineering (IAN)	2
Construction project (optional interdisciplinary)	P	CEWM	Cepuder P, Ertl T, Fürst J, Langergraber G, Mader H, Mayr E, etc.	Department of Water - Atmosphere - Environment, Department of Landscape, Spatial and Infrastructure Sciences, Department of Civil Engineering and Natural Hazards	6
Master´s thesis seminar	SE	CEWM			2

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Elective courses (selected)					
Risk Management and Resource Protection					
Integrated flood risk management	L	CEWM	Holzmann H, Habersack H, Schober B	Institute of Water Management, Hydrology and Hydraulic Engineering (IWHW)	3
Sustainability, Protection of Resources and Natural Hazards (compulsory in the module)	L	CEWM	Fiebig M	Institute of Applied Geology (IAG)	3
Protection and mitigation measures against natural hazards	L	CEWM	Hübl J (Mögele C)	Institute of Mountain Risk Engineering (IAN)	3
Risk management and vulnerability assessment	SE	CEWM	Papathoma-Köhle M, Thaler T	Institute of Mountain Risk Engineering (IAN)	3
Landslide hazards	SE	CEWM	Mergili M, Straka W, Zangerl C	Institute of Applied Geology (IAG)	3
Environmental risks - introduction to risk analysis	L	CEWM	Gazsó A	Insitute of Safety and Risk Sciences	2
Technology assessment	SE	CEWM	Liebert W, Drapalik M, Gufler K	Insitute of Safety and Risk Sciences	3
Environmental statistics	L	CEWM	Laaha G (Schlögl M)	Institute of Applied Statistics and Computing (IASC)	3
Soil water protection	L	CEWM	Cepuder P	Institute of Hydraulics and Rural Water Management (IHLW)	2
Soil protection	L	CEWM	Wenzel W	Institute of Soil Research (IBF)	3
Development and application of water erosion models	L	CEWM	Klik A	Institute of Hydraulics and Rural Water Management (IHLW)	2

6.3 Geotechnical and Hydraulic Engineering (GHE)

The master's degree programme in "Geotechnical and Hydraulic Engineering"established at TU Graz provides students with an in-depth education in engineering, focussing on the field of civil engineering and its application and, through the three separate specialisation subjects offered, Soil Mechanics, Rock Mechanics and Hydraulic Engineering, is oriented towards the current international development of engineering subdisciplines. The degree programme reflects the principle of research-led teaching. In addition to providing detailed specialist, theoretical knowledge, particularfocus is laidon providing practical, social and media competencies. In extended exercises in laboratories and outdoors as well as on excursions, students learn to independently develop concepts and to put them into practice (TU Graz, 2015)

Occupational fields

Graduates of the master's degree programme "Geotechnical and Hydraulic Engineering" are prepared for employments in the following fields of activities:

- Geotechnics
- Soil mechanics
- Foundation engineering
- Rock mechanics
- Tunnelling

- Hydraulics
- Hydraulic engineering
- Urban water management

Scope and classification

In the scope of this master's degree programme courses in the extent of 120 ECTS have to be taken. The courses are subdivided into the following classification:

- Compulsory courses: 27.5 ECTS
- Master thesis: 30 ECTS
- Elective courses: 50.5 ECTS
- Elective courses (soft skills): 6 ECTS
- Free elective courses: 6 ECTS

Within the scope of elective courses two out of three subjects (Soil Mechanics, Rock Mechanics and Hydraulic Engineering) have to be selected. The subject Hydraulic Engineering, including courses related to natural risk management, and all essential compulsory courses are listed in Table 4.

Table 4Compulsory courses and selected elective courses of the master's degree programme "Geotechnical and Hydraulic Engineering"

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Compulsory courses					
Engineering Geological Investigation	L	GHE	Bitenc M, Harer G, Kieffer D	Institute of Applied Geosciences	3
Finite Element Method	L	GHE	Fries T, Steidl J	Institute of Structural Analysis	3
Geotechnical Monitoring	L	GHE	Ehrhart M, Lienhart W	Institute of Engineering Geodesy and Measurement Systems	4
Hydraulic Engineering	L	GHE	Zenz G, Shahriari S	Institute of Hydraulic Engineering and Water Resources Management	4
Hydraulics 1	L	GHE	Zenz G	Institute of Hydraulic Engineering and Water Resources Management	1.5
Hydraulics 1	SE	GHE	Knoblauch H	Institute of Hydraulic Engineering and Water Resources Management	1.5
Petrology	PE	GHE	Hippler D, Klammer D	Institute of Applied Geosciences	1
Petrology	L	GHE	Hippler D, Klammer D	Institute of Applied Geosciences	1.5
Rock Mechanics and Tunnelling	L	GHE	Pötsch M, Schubert W	Institute of Rock Mechanics and Tunnelling	4
Soil Mechanics and Foundation Engineeering	L	GHE	Ausweger G, Marte R, Pichler P, Schweiger H	Institute of Soil Mechanics and Foundation Engineering	4

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Elective courses (selected)					
Hydraulic Engineering					
Field Excursion Hydraulic Engineering	P	GHE	Schneider J, Hammer A, Shahriari S, Staudacher E	Institute of Hydraulic Engineering and Water Resources Management	1.5
Fundamentals of Grouting	L	GHE	Kieffer D, Marte R	Institute of Applied Geosciences	3
Geotechnical Earthquake Engineering	L	GHE	Kieffer D, Lee H	Institute of Applied Geosciences	3
Hydraulics 2	L	GHE	Zenz G, Knoblauch H	Institute of Hydraulic Engineering and Water Resources Management	6
Hydrology	L	GHE	Muschalla D, Krall E	Institute of Urban Water Management and Landscape Water Engineering	3
Management of Risks and Disasters	L	GHE	Hammer A	Institute of Hydraulic Engineering and Water Resources Management	4
Master Project Hydraulic Engineering	SE	GHE	Knoblauch H, Schneider J, Hammer A, Shahriari S, Staudacher E	Institute of Hydraulic Engineering and Water Resources Management	5
Project Planning and Supervision of Hydraulic Structures	L	GHE	Zenz G, Hammer A	Institute of Hydraulic Engineering and Water Resources Management	5
River and Sediment Hydraulics	L	GHE	Knoblauch H, Schneider J	Institute of Hydraulic Engineering and Water Resources Management	3
Seismic Evaluation of Water Retention Structures	L	GHE	Zenz G, Shahriari S	Institute of Hydraulic Engineering and Water Resources Management	3
Testing Technology and Laboratory Tutorial in Hydraulics	P	GHE	Schneider J, Shahriari S	Institute of Hydraulic Engineering and Water Resources Management	4

6.4 Civil Engineering (CE)

The master's degree programme in "Civil Engineering" of Vienna University of Technology (TU Wien, 2013) provides students with an in-depth education in engineering, focussing on the field of civil engineering and its application. The degree programme reflects the principle of research-led teaching. In the scope of the master's degree programme attention is given to an interdisciplinary education supporting technical engineering, cognitive and practical as well as social and innovative competencies.

Occupational fields

Graduates of the master's degree programme "Civil Engineering" are prepared for employments in the following fields of activities:

- Structural engineering
- Geotechnics
- Construction management
- Traffic and mobility

- Water & resources

Scope and classification

In the scope of this master's degree programme courses in the extent of 120 ECTS have to be taken. The courses are subdivided into the following classification:

- Compulsory courses: 52 ECTS
- Master thesis: 30 ECTS
- Elective courses: 21 ECTS
- Project: 8 ECTS
- Free elective courses (+soft skills): 9 ECTS

Within the scope of compulsory courses two out of six subjects (Structural Engineering I, Structural Engineering II, Geotechnics, Soil Mechanics, Construction Management, Traffic and Mobility, Water and Resources) have to be selected. The subject of Geotechnics, including courses related to natural risk management, is depicted in Table 5.

Table 5Selected compulsory courses of the master's degree programme "Civil Engineering"

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Compulsory courses (selected)					
Geotechnics					
Rock Engineering and Tunneling	L	CE	Adam D	Institute of Geotechnics	2.5
Soil mechanics and geotechnical engineering 2	LU	CE	Blovsky S	Institute of Geotechnics	2
Soil Dynamics	L	CE	Adam D, Kopf F	Institute of Geotechnics	1
Ground exploration and rock classification	SE	CE	Hofmann R, Bilak A	Institute of Geotechnics	2.5
Applied rock mechanics	L	CE	Poisel R, Preh A	Institute of Geotechnics	3
Applied and technical petrology	L	CE	Rohatsch A	Institute of Geotechnics	2
Geotechnics and Natural Hazards	SE	CE	Hofmann R	Institute of Geotechnics	2
Ground Engineering and Soil Mechanics 2	L	CE	Adam D	Institute of Geotechnics	3
Special foundations	L	CE	Breit K	Institute of Geotechnics	2
Geosynthetics in Civil Engineering	L	CE	Oberreiter K	Institute of Geotechnics	2
Environmental geotechnics	L	CE	Brandl H	Institute of Geotechnics	2.5
Applied rock mechanics	SE	CE	Preh A	Institute of Geotechnics	2
Applied and technical petrology	LU	CE	Rohatsch A, Ban M	Institute of Geotechnics	2
Restoration and conservation of buildings and objects made stone	SE	CE	Rohatsch A, Ban M	Institute of Geotechnics	1.5
Finite Difference Modelling in Geoengineering	SE	CE	Preh A	Institute of Geotechnics	2.5
Geology and traffic constructions	L	CE	Bilak A	Institute of Geotechnics	3
Underground excavation design	SE	CE	Zettler A	Institute of Geotechnics	1.5
Applied rock mechanics	EX	CE	Poisel R	Institute of Geotechnics	2

7 Literature

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