



# Geographic information systems in mountain risk and disaster management



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## ABSTRACT

Mountain risk and disaster management (MRDM) and natural hazards are in alpine countries a national task. Natural hazards in alpine spaces are represented by floods, avalanches, landslides, rock falls and debris flows. MRDM is a very complex system which includes many technical and administrative components. MRDM is based on legal acts and regulations enforced by different federal political levels and departments. A big desire of all involved participants in MRDM is to get simple solutions in this complexity. Austrian Service for Torrent and Avalanche Control has to keep a TAC. With the support of geographic information systems (GIS) it was possible to create a digital TAC. The digital TAC is diverted into different modules: torrent areas, avalanche areas, hazard zone maps, etc. Each module has its own character, but act also interactive. In view of data security TAC has no public access. For public information supply objects can be exported from digital TAC. Only when technical and legal work of an object is correct it can be send through a data tunnel to WebGIS portals with permanent public access for further public use. This paper gives a basic insight into digital TAC supported by GIS which is used in the offices of Austrian Service for Torrent and Avalanche Control.

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## 1. Introduction

The risk resulting from natural hazards can be derived from the combination of parameters of physical processes and the damage potential (Keiler, 2004). The damage potential or vulnerability is also influenced by the development of the society. The alpine society has undergone enormous socio-economic changes; the shift from an agricultural society to a modern service industry and leisure oriented society is reflected by an increasing usage of the Alps as an area of settlement, economic activities and leisure (Bätzing, 1993). The quality of the buildings and their equipment has increased significantly, mainly in order to meet the demands of the tourism industry, reinsurance companies have been pointing out the worldwide trend of increasing damage sums caused by natural hazards. Even though the damage potential has been taken into account more frequently (Keiler, 2004). Controlling natural hazards is a national task of paramount importance to ensure maximum safety, through sustainable strategies in the integrated risk management of natural hazards in mountainous watersheds (Turconi, Nigrelli, & Conte, 2014).

Mountain risk and disaster management (MRDM) works mainly with natural hazards in alpine regions comprising flooding, avalanches, landslides, rock falls and debris flows. In the mountains torrents and avalanches become strengthened in catchment areas and cause hazards which threaten urban areas with flooding and avalanche impacts (Graphical Abstract, Fig. 1).

Fig. 2 describes a comprehensive circle of disaster, risk and crisis management (FAO, 2004). One half reflects crisis management after disaster and the second half shows risk management before next disaster. The head of the crisis management is mostly the municipal council supported by firefighters and if necessary by volunteers and army. The period of mitigation and prevention pursues the aim to reduce the risk of damage by disaster. It comprises analysis of past disaster, creation of concepts by research and development, project planning and realization, identification of vulnerability with the help of hazard zone maps and financial planning.

## 2. Austrian approach to MRDM

In Austria MRDM is based on federal law, regulations and ordinances. Austria is politically divided into federal provinces and municipalities. Each federal political level has its own legal acts and

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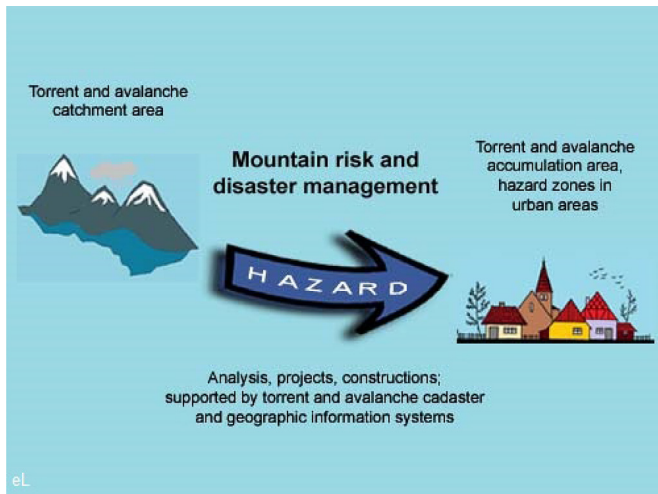


Fig. 1. Torrents and avalanches become strengthened in catchment areas and cause hazards which threaten urban areas, Graphical Abstract.



Fig. 2. Disaster, risk and crisis management circle; crisis management happens after disaster, risk management before next disaster (FAO, 2004).

regulations which are equally applied and complement each other (Table 1).

Based on these regulations, Austrian Ministry for Agriculture, Forestry, Environment and Water Management is in charge of strategic steering in MRDM. In Austrian water bodies exists a separation in torrents and rivers. This has mainly a historical reason but which is still existing. On the one hand, in the federal Water Act, legislated in 1959 and adapted to the European Water Framework Directive (Directive 2000/60/EC), the administration for river management is delegated to the federal provinces. Each Austrian federal province has own Technical Water Engineering and Water Management Offices.

On the other hand, in 1884, when Austria was still part of the Austrian–Hungarian monarchy Austrian Service for Torrent and Avalanche Control was founded by a torrent regulation law to act against natural hazards caused by torrents. The main mission was to plan, develop and finance constructions. Today torrents are together with avalanches regulated by the federal Forest Act, legislated in 1975. Hence, Austrian Service for Torrent and Avalanche Control and Technical Water Engineering and Water Management Offices of the Provincial Governments administrate together with municipalities MRDM.

Technical terms are defined and described by Austrian federal Forest Act of 1975. A torrent is a permanent or temporary water body which takes and carries dangerous amounts of sediments from the catchment area and its river bed with a strong rise in the water level within a short period of time and stores these sediments inside or outside the river bed or in another water body (Republik Österreich, 1975). This characteristic can happen only in mountainous regions, therefore torrents exist only there. Lowlands are mostly free of torrents (see Figs. 2 and 3 in Lepuschitz, submitted for publication).

An avalanche consists of huge snow masses which causes hazardous situations and damage because of its kinetic energy or air pressure gained from steep slopes and trenches (Republik Österreich, 1975).

For better administration the Forest Act defined in Austria the first time that Austrian Service for Torrent and Avalanche Control had to keep a torrent and avalanche cadaster (TAC, Republik Österreich, 1975). Already in the 80's and beginning 90's a research group started the realization of a TAC but first only in an analog way.

Another field of work is to develop hazard zone maps for each village which is affected by torrents or avalanches. Each torrent and avalanche has a catchment area which causes red and yellow hazard zones in settlements. Other hazard zones which are caused by rock fall, erosion or landslips are shown as brown hazard zones. Furthermore, it's possible to include other colored hazard zones for future measures. Future measures can be active or passive. Active measures are e.g. retention basins in torrents (blue zones) and passive measures are e.g. natural areas where shape and quality of the soil shall not be changed (violet zones). The areas of hazard zones are to be held free from other buildings (Republik Österreich, 1976).

A hazard zone map has to have a map part and a text part, the map part includes maps for hazards and for hazard zones. The text part describes contents of the maps and all official steps of the developing process. An Austrian statutory technical ordinance defines the design of hazard zone maps in Austria (Republik Österreich, 1976).

To develop a hazard zone map is a complex process, it includes also the collection of statements of inhabitants living in respective village. It is the hydrologists who more and more seek to collect

Table 1  
Austrians regulations about MRDM (Leitgeb & Rudolf-Miklau 2004).

Political level	Law
Federal level	<ul style="list-style-type: none"> <li>• Water Act</li> <li>• Forest Act</li> <li>• Torrent Control Act</li> <li>• Water Construction Financing Act</li> <li>• Disaster Relief Fund Act</li> <li>• Ordinance on Hazard Zone Mapping</li> <li>• Guidelines on Hazard Zone Mapping</li> <li>• Technical Directive for Torrent and Avalanche Control</li> <li>• Directive for Cost-Benefit-Analysis on Torrent and Avalanche Control Measures</li> </ul>
Federal State level	<ul style="list-style-type: none"> <li>• Civil Protection Acts</li> <li>• Areal Planning Regulations</li> <li>• Building trade Acts</li> </ul>
Local level (municipalities)	<ul style="list-style-type: none"> <li>• Hazard Zone Maps of Torrents and Avalanches</li> <li>• Area planning scheme</li> <li>• Local development concepts</li> <li>• Development scheme</li> <li>• Planning and building permissions</li> <li>• Alarm and action plans for catastrophes</li> </ul>

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