GEOMORPHOLOGICAL HAZARD CAUSED BY CLIMATE CHANGE AND ITS IMPACTS ON HIKING TRAILS AND ROUTES

A CASE STUDY FROM THE GROSSGLOCKNER-PASTERZE GLACIER AREA (HOHE TAUERN/AUSTRIA)

Katharina Kern[1], Gerhard K. Lieb[1], Gernot Seier[1], Ulrich Strasser[1] and Andreas Kellerer-Pirklbauer[1]

INTRODUCTION

In high mountain areas, which are characterized by steep slopes and great altitudinal differences, mass movements are very common processes. This study in particular focuses on geomorphological processes like rockfalls, rockslides, debris flows and other gravitational mass movements that reshape the land surface by erosion, transport and deposit of rocks. When it comes to an interaction of such naturally occurring processes with human activity, they can quickly become natural hazards that may cause loss of human life or damage to property, infrastructure and the environment.

For a region like the Alps, where the warming is higher than the global average, regional climate models generally agree that temperatures are rising, the precipitation is likely to undergo seasonal shifts and higher interannual variability characterized by an increase in extreme rainfall events will occur. Since mass movements, among other factors, are driven by climate, changes in either temperature or precipitation may also change their frequency, magnitude and range. In addition, two direct impacts of climate change, glacier retreat and permafrost degradation, intensify the situation in high mountain areas. Both processes result indirectly in an increase in potentially mobilizable material for various mass movements. Furthermore, glacier retreat and mass movements can also negatively affect the accessibility of mountain trails and routes. Besides an increase in the direct risk, e.g. hikers getting hit by a falling rock, the indirect risk caused by a constantly changing surface, e.g. crossing a glacier can become more difficult and demanding or rock fall can make a trail impassable, will significantly rise in future.

For settlements and transport routes an elaborate system of permanent and temporary/active and passive protective measures has already been developed in the late 19th and for touristic intensively used areas (e.g. ski slopes) in the 20th century. These measures are embedded in an integral risk management and are implemented almost consistently all over Austria. However, this is not always the case for alpine (marked) trails and high alpine (unmarked) routes. For this reason more and more people are dealing with the question of how to ensure the safety for people walking on trails and routes. The aim of this study is to develop geomorphological hazard and vulnerability maps on a regional scale to estimate the present and future risk potential for Alpine tourists and infrastructure caused by rockfall and other denudation processes. To achieve this goal, a tool is needed that is able to exactly identify dangerous spots. This tool should be extensively and easily comprehensible and thus facilitate the implementation of targeted measures.

METHODS

The Grossglockner-Pasterze glacier area, one of the most visited high mountain areas in Austria, was selected as a study area for this research. Within the project rockfall/debris fall as well as denudation processes were modelled in the study area, whereas here, the term denudation processes is understood as a collective term for shallow landslides, debris and mud flows as well as sheet erosion. For this purpose, on the one hand, potential source areas for mass movements were detected by disposition models and on the other hand, range and dispersal of the downward-moving rock material were

[1] Department of Geography and Regional Sciences, University of Graz, Heinrichstrasse 36, 8010 Graz, Austria (phone: +43-316-380-8830; e-mail: katharina.kern@uni-graz.at)

determined by a process model. This approach makes it possible to spatially differentiate the processes in erosion, transport and deposit areas. Since these areas carry different risks, this information is of great importance for the subsequent creation of the hazard maps.

The disposition model is based on the assumption that certain geo-factors that triggered a mass movement in the past will most likely cause the same processes in the future. Due to the fact that not all gravitative mass movement processes are triggered by the same factors and do not proceed in the same way, two different disposition and process models, one for rockfall and one for other denudative processes were developed. The information about potential rockfall and denudation source areas was obtained by combining various types of information (e.g. slope, geology, vegetation). Then potential mobilizable rock and debris masses needed to be estimated. Therefore, data about the average maximal thickness of the active layer over permafrost in the study area in combination with information about aspect, altitude and geology was used to calculate the potentially mobilizable masses. The next major step was the process modelling. This was obtained by a mass-conserving multiple direction flow propagation algorithm which uses information from the disposition model and a digital elevation model (DEM) to determine the transport and deposit areas of moving rock/debris masses. After the modelling, the processes were assessed and served as a basis for the generation of a geomorphological hazard map that subdivides the study area into four hazard classes. In addition to the estimation of the present risk, a potential future scenario 2030 was created, where additional climate data and information about glacier retreat as well as permafrost degradation were considered for the development of the geomorphological hazard map. By overlaying the hazard maps with trail- and route-network information, vulnerability maps were created for the recent situation as well as for the future scenario. These maps make it easier to recognize how severe certain trail or route segments are affected by dangerous processes. In a final step, local stakeholders reviewed the maps and evaluated them with regard to possible measures. These include local (e.g. closing down or new installation of trails) and organizational measures (e.g. installation of a trail information system) as well as measures to improve the training of people who want to spend their leisure time in high mountain areas.

RESULTS AND CONCLUSIONS

The results of the study clearly show that in a high mountain area like Grossglockner-Pasterze, where the risk potential is in any case high, morphodynamic processes tend to become bigger and more frequent in the future. Only 15.5% of the study area is classified as areas were hazards are barely possible in 2010. In contrast, in 40.1% of the study area hazards have to be expected and in 27.1% hazards are more than likely. In the 2030 scenario, areas where risks are possible are expected to increase to 40.6% and 29.7% respectively. When focusing on the trail network, the results show that only 1.8% of the 108 kilometre of trails in the study area are possibly getting less dangerous in future, whereas 5.5% of the trails are 2030 classified in higher hazard classes than in 2010.

In addition to the changing environmental conditions, by tendency more and more people are visiting high mountain areas. The recreational behaviour of people changed and better equipment than in the past as well as a better safety net (e.g. the possibility of calling for help by cell phone) make some Alpine tourists take more risk than they should.

The study shows that climate change is already a challenge for the construction and maintenance of alpine trails and routes and will more than likely become a bigger one in future. To enhance the safety of Alpine tourists in a long run, a close collaboration of all involved parties is crucial.

Keywords: mass movements, disposition modelling, process modelling, hazard maps, vulnerability maps