University of Zurich[UZH]

**Department of Geography**

University of Zurich
Department of Geography
Winterthurerstrasse 190
CH-8057 Zurich
www.geo.uzh.ch

Charles University
Faculty of Science
Prague

**Prof. em. Dr. Wilfried Haeberli**
Phone +41 44 635 51 93
Fax +41 44 635 68 41
Mail: wilfried.haeberli@geo.uzh.ch

# Assessment of the PhD dissertation submitted by Adam Emmer

## Dynamic of evolution and hazardousness of lakes in the Cordillera Blanca (Peru)

In international policy-related programs of climate-system observations, the rapid shrinking of most glaciers at global scale is often called a “unique demonstration object” of climate change. Not only is snow and ice melting due to warming conditions a common experience for many people on Earth but observation of striking changes in nature and increasingly also via publicly accessible satellite imagery is easily possible. Awareness of on-going climate and glacier change is therefore growing. Science provides exact numbers and develops numerical models to interpret past evolution and to anticipate realistic scenarios of future developments. Such information clearly documents the fact that many mountain ranges have already lost large parts of their glaciers and are likely to essentially become de-glaciated within decades. As a consequence, awareness is also rising concerning the rather dramatic landscape changes, which are taking place in cold mountain regions. An emerging field of inter- and trans-disciplinary cold-regions and high-mountain research has started to develop tools for anticipating future environments with their challenges – options for use as well as hazards/risks. A strong focus among the various aspects involved is thereby on the formation of lakes where glaciers retreat or disappear. Such lakes can be attractive for tourism, hydropower or water supply but also strongly increase risks far beyond historical precedence in the region. Sudden outbursts of glacial lakes have indeed caused a lot of local damage up to regional disasters. A rapidly growing literature documents the involved processes and phenomena on the physical as well as on the socio-economic and cultural side. It provides fundamentally important information on how to assess new hazards and how to deal with them. Adam Emmer’s work developed within this framework.

The PhD thesis of Adam Emmer deals with high-mountain lakes in the Cordillera Blanca of Peru and their susceptibility with respect to hazardous processes. A long, fascinating, complex and sometimes tragic history of human livelihood, shrinking glaciers and new lakes exists in this region. Peruvian authorities as well as a good number of international scientists have been working on the involved questions for decades. In fact, perhaps the richest experience worldwide has been built up here with protective engineering work to increase lake safety in many cases. Rapid changes in environmental as well as socio-economic conditions, however, require continued efforts in view of climate change adaptation and societal needs. The team of geoscientists from the Charles University

of Prague has been involved for many years now in the corresponding international collaborative efforts. The supervision of the presented work by Vít Vilímek and Jan Klimeš as well as the collaboration with Martin Mergili from Austria with their extraordinary knowledge, skills and experience thereby enabled investigations to be carried out at the very forefront of research in this domain of science. Productive contacts were also possible with the Unidad de Glaciología y Recursos Hídricos (UGRH) of the Autoridad Nacional del Agua (ANA) in Huaraz.

The presented thesis consists of a synthesis text (86 pages with extensive references) and nine appendices containing published papers. The synthesis text starts with a brief introduction and description of the region under study, followed by an outline of the applied methodology relating to hazard susceptibility assessments. The core of this methodology is made of decision trees systematically combining five outburst triggering scenarios – overtopping and dam failure caused by impact waves or floods from lakes higher in the catchment; earthquake leading to dam failure – with a large set of characteristics concerning the dams, the lakes and the surroundings. The approach is validated with seven lakes where outbursts had been documented. It is then applied to 64 lakes with surface areas > 100.000 $m^2$ after a statistical analysis of 882 lakes in the Huascarán National Park. Table 9 summarizes the results indicating where the considered scenarios are most likely to occur. This information can be seen as the key result of the study in view of practical reflections. The method is then also used to examine the effectiveness of remedial measures, which had been taken at nine lakes. This enables to show that the engineering work had indeed reduced but not completely eliminated the susceptibility with respect to possible outburst processes. The final part of the text describes the Palcacocha and Artizón/Jatuncocha cases, the debris-covered Jatunraju glacier with its strongly elevated sediment bed (not a rock glacier as suggested in the text) forming the original dam of Laguna Parón, and mentions landslide dams.

Solid facts and systematic analyses are reported, constituting the results from intense literature studies, extensive fieldwork and a thorough understanding of complex high-mountain environments. This precious material can form the basis for further critical reflection about important questions like the transparency of complex hazard assessment approaches, the applicability of the developed system for new lakes forming in future, concrete policy-related steps in practice, etc. By now, the real treasure of the presented work is the extraordinary number (nine) of excellent papers in outstanding international journals and scientific platforms. They are also the expression of efficient international collaboration at high scientific levels and are already now recognized as highly valuable contributions to the discourse and inter-/trans-disciplinary debate on climate change adaptation in rapidly and drastically changing cold-mountain environments.

I am pleased to recommend the research results presented by Adam Emmer for acceptance as a PhD dissertation by the faculty of the Charles University at Prague.

Zurich, 22 August 2017

Prof. em. Dr. W. Haeberli