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Analysis and mitigation of remote geohazards in high mountain areas of Tajikistan with special emphasis on glacial lake outburst floods

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Remote geohazard events in the mountains of Tajikistan have repeatedly caused disasters during the past decades. The rock avalanche of Khait in1949 and the glacial lake outburst flood (GLOF) in Dasht in 2002 are only two examples. However, the awareness among stakeholders and the local people is limited since the source areas are far away and the frequency of events is low.

The major objective of the research outlined here is to identify and to highlight potential source areas and pathways of remote geohazard events, particularly of GLOFs, in order to allow for well-designed mitigation procedures. The geohazard assessment was carried out in a four-step procedure:

• Pre-assessment: GIS and remote sensing techniques were employed for detecting potential source areas and pathways of remote geohazard processes. Relevant features were mapped from medium-resolution datasets and specific areas of interest were deducted from the mapping results.

• Helicopter survey: the areas of interest identified during the Pre-assessment were screened from the helicopter. The knowledge gained this way was used to select the areas for the field assessment.

• Field assessment: the areas of specific interest were visited in the field by international groups of 4 researchers. These areas were analyzed and mapped in detail and the level of hazard emanating from the lakes or slopes was estimated.

• Post-assessment. Based on the field assessment, areas of particular hazard were selected for further analysis. Scenarios of dam breaks and flood waves were built and the possible impact farther down the valley was assessed using computer models. Based on that, recommendations how to mitigate the hazard will be given to the relevant agencies and stakeholders as well as to the local population.

In the Southern Pamir, a number of growing glacial lakes was identified. Resulting flood waves could trigger process chains with catastrophic consequences for the population dozens of kilometres downstream. Most of these lakes are dammed by moraines containing some ice. A significant example for a lake dammed by a rock glacier is located in the Central Pamir. Currently, the dam appears stable, but further melting of the ice could lead to a progressive failure.

In the highest portions of the Pamir, glacial retreat and the development of glacial lakes has not yet reached the stage as observed farther South. However, future retreat, but also surging of glaciers in the area may result in new lakes. The Alai Mountains in North-western Tajikistan have experienced comparable processes in the past. However, damming of lakes by rainfall-triggered landslides has still been reported repeatedly.

Two major tectonic faults run through the territory of Tajikistan, allowing earthquake magnitudes of 7.5 and more. Whilst dams may be weakened by earthquakes, or flood waves may be generated by rock falls into the lakes, several lakes dammed by earthquake-triggered landslides do exist or have broken out. It is certain that new lakes of this type will develop in the future, but the size and exact location are hard to predict.

Targeted and well-planned mitigation measures are required to prevent that future remote geohazard events will evolve into disasters, or at least to reduce the magnitude of the disaster. This requires conversion of the knowledge gained during the assessment into strategies and procedures for reducing the risk, e.g. promoting the awareness and preparedness, initiating monitoring and technical measures, and installing emergency information systems. In order to enable the realization of all these activities, much emphasis was put on capacity-building of the local actors: all the relevant agencies, scientists, and stakeholders were involved already in the hazard assessment, and

specific training workshops were carried out.