GLACIAL LAKE OUTBURST FLOODS IN THE KARAKORAM MOUNTAINS, P.R. CHINA

EARLY WARNING AND CLIMATE CHANGE MONITORING

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INTRODUCTION

In the last decade, 5 glacial lake outburst floods (GLOF) damaged infrastructure and claimed human lives along Yarkant River, Xinjiang, P.R. China. The spontaneous floods are a threat for over 1 Mio inhabitants in the floodplains of Yarkant River and are causing an annual monetary loss of approx. 10 Mio Euro.

Yarkant River drains the Karakoram Mountains with a catchment area of approx. 53’000 km^2 and ranks as number one in terms of flood frequency and damages in Xinjiang. The glacial outburst floods with peak discharges of up to 6’000 m^3/s originate from a remote ice-dammed glacier lake at 4’750 m a.s.l. in the Shaksgam Valley, approx. 560 km upstream of the floodplains (Fig. 1). There, the Kyagar Glacier snout blocks the riverbed. Hence, a lake with a volume over 200 Mio m^3 has built-up in the past. Based on a Memorandum of Understanding between the Ministry of Water Resources of P.R. China (MWRC) and the Swiss Federal Department of the Environment, Transport, Energy and Communications (DETEC), it was decided to initiate a Sino-Swiss project to improve risk assessment and mitigation with respect to climate change, combining various technologies and know-how. The project is supported by a cooperation between the Swiss Agency for Development and Cooperation (SDC) and the Federal Office for the Environment (FOEN).

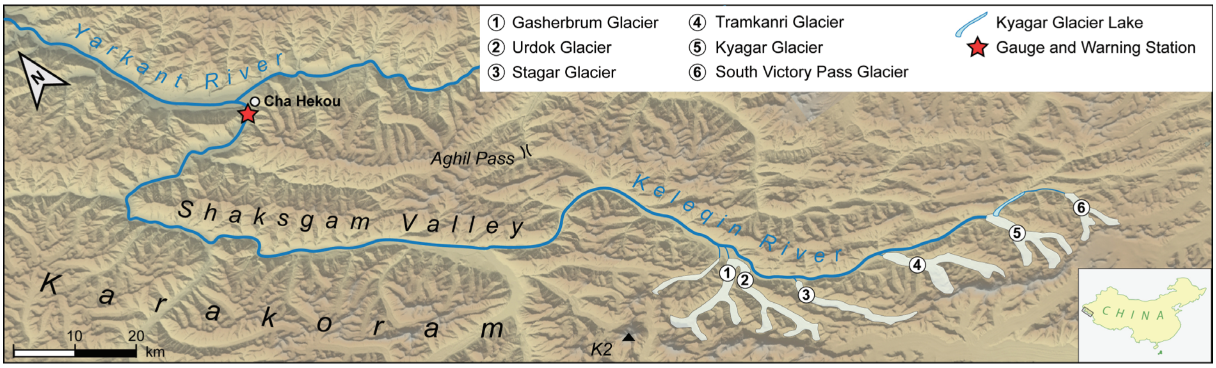

Fig. 1 Keleqin River and glaciers in the upper Shaksam Valley, Karakoram Mountains, P.R. China.

GOALS AND ACTIVITES

The activities aim to improve the management of the high flood risks of Yarkant River, predominantly caused by glacial lake outburst floods and the long-term monitoring of the respective glaciers and outburst hazards. The actions are structured into three phases: 1) Establishment of an Early Warning System (EWS) for GLOFs (realized in 2011); 2) Risk management for the potential flood areas (to be realized in 2012); 3) Climate Change monitoring and analysis (starting 2011).

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PROCEDURE FOR EARLY WARNING AND MONITORING

Because the hazardous glacier lake is situated in a very remote area, the methods focus on remote sensing and automatic terrestrial observation and warning stations: As a first step, a detailed digital elevation model (DEM) of the glacier lake was generated using high-resolution optical satellite images. Based on the DEM and periodically tasked high-resolution Synthetic Aperture Radar (SAR) images, both the evolution of the glacier lake and the glacier morphology were observed within a time interval of 11 days. The actual lake volume was calculated and the current hazard level was analyzed and transmitted to the Chinese decision makers. In addition to remote sensing techniques, a terrestrial solar powered gauge and warning station was installed along Keleqin River, approx. 200 km downstream of Kyagar Glacier Lake. Radar sensors are continuously logging the water level and pictures of Keleqin River are taken. All data is automatically transmitted by satellite communication to the decision makers. GLOFs typically show an obvious peak with rapid rising and falling water levels. In case of a detected GLOF, an automatically generated alarm-signal will immediately be sent to mobile phones of the Chinese authorities. Thus, emergency actions can be initiated. After the alarm-signal has been transmitted from the gauge and warning station, approx. 22 hours remain before the flood will reach the settlement area in the floodplains.

RESULTS

Based on remote sensing analyses, a small glacial lake with a volume of approx. 95’000 m^3 has been observed from late July to Mid-September 2011. The associated hazard potential for GLOFs was thus very low. In late autumn of 2011, the glacial lake drained through a sub-glacial drainage system without causing any damage to the settlement area. The automatic gauge and warning station is operational. Both water level fluctuations and EWS functionality are continuously monitored.

DISCUSSION

Recent studies suspect a relationship between floods and climate change, indicating that GLOFs are linked to increasing temperature (Chen, 2010). Because the potential volume of Kyagar Glacier Lake strongly depends on the thickness of its blocking ice-dam, mass-balance calculations in terms of accelerated melting of Kyagar Glacier are crucial. Such calculations are needed to define future hazard scenarios and to plan protection measures. Therefore, climate change monitoring based on remote sensing is another key element of the on-going project.

CONCLUSIONS

The EWS is one of the key elements within the project. In remote areas, where no structural measures are practicable, the implementation of an automatic EWS based on remote sensing and terrestrial observation stations proved to be efficient and could significantly reduce damages in the floodplains. On one the hand, glacial lakes are linked to complex glaciological processes, remote mountain areas and climate change. On the other hand, the damage potential in the floodplains and the vulnerability of society is constantly growing, as a result of the rising population density combined with an increase of economic assets in risk zones. All these specific parameters need to be considered in cooperation with the decision makers. The Sino-Swiss project is based on a strong collaboration and experience exchange between experts from both countries which aim to implement practicable, cost-efficient and sustainable measures.

REFERENCES

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